PARENTHOOD AND PARENTS' COGNITIVE HEALTH IN THE UNITED STATES

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ABSTRACT

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The linkage between parenthood and cognitive health has not been explored in-depth in the United States. This dissertation contributes to the broad literature on parenthood and parental well-being by examining how parental status, parent-child relationship quality, and history of fertility influence parents' cognitive functioning as well as potential gender variations. I use three empirical studies based on national representative, longitudinal datasets to address these questions. The first study examines the association between parental status in later life and older parents' risk of cognitive impairment. The results suggest that being childless or having only stepchildren is a potential risk factor for cognitive impairment, while having more adult children, especially one or more adult daughters, is a possible protective factor for parents' cognitive health. The second study investigates the impact of relationship quality between older parents and children on their parents' cognitive functioning and how this association varies by parents' gender. The results indicate that both greater contact frequency with children and relationship support from children are associated with higher initial cognitive functioning. In contrast, relationship strain with children is associated with lower initial cognitive functioning for older parents. Moreover, contact frequency is associated with slower cognitive decline, while a relationship strain triggers a faster cognitive decline. These associations are more pronounced for older mothers than older fathers. The third study focuses on the association between fertility history (i.e., age at first birth and parity) and risk of cognitive impairment among older parents. The findings suggest a U-shaped relationship between a parent's age at first birth and risk of

cognitive impairment for both fathers and mothers. However, older age at first birth is associated with mothers' risk more than early age. Socioeconomic status plays a strong role in reducing the effects of age at first birth on parents' cognition, especially for mothers. High parity also increases mothers' risk of cognitive impairment, but not fathers. My dissertation addresses the gap of knowledge in social determinants of cognitive health by examining the dynamics of parenthood in later life and identifying older adults who have more harmful exposure to the risk of cognitive impairment. The findings can speak to medical practitioners, social workers, and policymakers so that they could make more effective interventions to promote older adults' cognitive well-being as well as successful aging.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Parenthood is historically characterized as a normative life experience and social roles that has been demonstrated as a factor related to parental health outcomes and quality of life (Bures, Koropeckyj-Cox and Loree 2009; Carr and Utz 2020; Mirowsky 2005; Nomaguchi and Milkie 2020; Umberson, Pudrovska and Reczek 2010). However, the increasing longevity, declining fertility rates, and increasing remarriage and stepfamilies all make parenthood experience more complex than a few decades ago, which requires us to reconsider its effects on well-being in today' U.S. society (Carr and Utz 2020; Umberson et al. 2010). The past three decades also witnesses a trend of delayed transition into adulthood: it takes longer time for young adults to achieve economic independence than in the past, leading to extended years of active parenting and potential burdens for mid-life and even later-life parents (Furstenberg 2010; Fingerman, Huo and Birditt 2020; Nomaguchi and Milkie 2020). Moreover, for older parents experiencing physical or cognitive decline, children, especially adult daughters, are often the primary caregivers who provide parents with intensive support, both economically and emotionally (Carr and Utz 2020; Umberson et al. 2010). Yet, despite the fact that parenthood influences various parental health outcomes, the linkage between parenthood and parents' cognitive health is not fully understood.

With the rapid population aging in the U.S., cognitive impairment has emerged as a rising public health concern because of its high prevalence, high costs of health services, and increased need for long-term caregiving (Alzheimer's Association 2020; Ray and Davidson 2014). More than 5 million older adults over age 65 in the U.S. were living with Alzheimer's dementia (AD) in 2020 (Alzheimer's Association 2020). Scientific efforts have long been made to explore the cause and progression of cognitive decline, but a majority of such efforts are either from behavioral or clinical data with non-representative small samples (e.g., Karim et al. 2016; Najar et al. 2020). Although recent population-based studies suggest that individuals' family relationships have a long-term impact on their cognitive health in later life (e.g., Liu et al. 2020; Zahodne et al. 2019), the effect of parenthood, one of the most important indicators of family formations and relations, is still understudied.

This dissertation includes three empirical studies based on longitudinal, population-based data to explore the multi-dimension of parenthood and its association with older parents' cognitive health. A conceptual framework is displayed in Figure 1-1. Specifically, the first study examines the association between parental status and parents' risk of cognitive impairment. The second study discusses whether parent-child relationship quality can link to parents' cognitive functioning. The third study focuses on parents' fertility history and potential mechanisms linking to parents' risk of cognitive impairment in later life. In the second and the third studies, gender variations between fathers and mothers are also examined. These findings can speak to policymakers and medical workers who can help to provide more comprehensive person- and family-centered long-term support or services to vulnerable older adults as well as their family in their caregiving roles (Reinhard et al. 2016; Redfoot et al. 2013).

CHAPTER 2

PARENTAL STATUS IN LATER LIFE AND PARENTS' RISK OF COGNITIVE IMPAIRMENT

INTRODUCTION

Parental status has been characterized as a normative life experience and a crucial role transition that has been shown to be a factor related to parental well-being (Bures et al. 2009; McLanahan and Adams 1987; Umberson et al. 2010; Zhang and Hayward 2001). However, the demographic transition, with increasing longevity, declining fertility rates, and increasing remarriage and stepfamilies, all make the parenting experience more complex than a few decades ago, which requires researchers to reconsider its effects on parental well-being in U.S. society today (Carr and Utz 2020; Nomaguchi and Milkie 2020; Umberson et al. 2010). Being a parent or not can shape individuals' life context in significant ways, and its impact on health can vary across parents' life span (Nomaguchi and Milkie 2020). Yet, the vast majority of research in this area has focused on how parenting minor children influences younger parents' psychological well-being (e.g., Nomaguchi 2012). Empirical evidence on the effects of adult children on parental well-being in later life, especially on parents' cognitive health, is limited in the United States.

Cognitive impairment has emerged as a major public health concern because of high prevalence rates, high health care costs, and the high burden they impose on patients and caregivers, both economically and emotionally (Alzheimer's Association 2020; Ray and Davidson 2014). Among primary dementia caregivers, over half take care of their parents, and over one-third of dementia caregivers are daughters (Alzheimer's Association 2020). Childless older adults living with cognitive impairment are among the most unsupported and socially isolated populations, being more likely to experience loneliness, elder abuse, and inability to access formal care (Read and Grundy 2017; Sundström et al. 2014; Xu et al. 2018). Although an increasing number of studies have examined how onset or progression of cognitive impairment influences the relationship between older parents and children, little is known about how having adult children can be a protective or risk factor affecting parents' risk of cognitive impairment.

This study explores the linkage between parental status in later life and parents' risk of cognitive impairment using longitudinal data from the National Health and Aging Trends Study (NHATS), 2011-2019. I focus on four measures of parental status in parents' later life: the presence of adult children, number of adult children, gender of adult children, and step-parenthood. The analysis addresses four major research questions: (1) Is having adult children related to a lower risk of cognitive impairment for older parents? (2) Do older parents who have more adult children show a lower risk of cognitive impairment? (3) Does the gender of adult children matter to older parents' cognitive health? (4) Do stepchildren benefit older stepparents' cognitive health?

A LIFE COURSE PERSPECTIVE

The life course perspective has been widely applied in understanding how parental status links to parents' health outcomes (Koropeckyj-Cox, Pienta and Brown 2007; Nomaguchi and Milkie 2020; Umberson et al. 2010). First, the life course perspective emphasizes individual variations in different social contexts throughout the life span (Elder 1995). Being a parent or not can significantly shape an adult's life contexts, determining changes in socioeconomic status, labor market participation, and marital quality that can in turn affect individuals' health outcomes in both the short and long term (Koropeckyj-Cox et al. 2007). Second, the notion of "linked lives" suggests the interconnectedness between parents and children (Bengtson, Elder and Putney 2012; Elder 1994). Parents' lives are mostly embedded in relationships with their children, suggesting that children's characteristics and lives have implications for parents' lives, and further influence trajectories of change in parents' well-being over time (Bengtson et al. 2012; Elder 1995; Umberson et al. 2010). Last, the life course perspective helps to locate people in a matrix of age-graded family relationships, which can provide insight to contextualize the effects of parenthood on older parents' well-being in later life. Prior studies mainly focused on parenting minor children and younger parents' well-being (e.g., Nomaguchi 2012), which was less powerful in explaining how adult children influence older parents' lives. Therefore, it is important to consider the dynamics of parental status over the life course.

MECHANISMS LINKING PARENTAL STATUS AND COGNITIVE HEALTH

Theoretically, there are three major mechanisms that explain how and why parental status may link to parents' well-being: *the support model, the social control process,* and *the stress model*. *The support model* suggests that family members (i.e., spouse, children, relatives) often support individuals financially, instrumentally, informationally, and emotionally, which are potential protectors of well-being in later life (Liu et al. 2020; Nomaguchi and Milkie 2020; Umberson et al. 2010). First, adult children can support older parents by providing parents with economic resources, for instance, by improving household wealth and purchasing insurance, medical treatment, and care service (Knoester 2003; Umberson, Thomeer and Williams 2013). Second, children can satisfy parents' emotional needs by providing psychological support, which often increases parents' life satisfaction and can play the role of stress buffer by diminishing the negative effects of life strains (e.g., financial loss, death of spouse, health decline) on parents' well-being (Knoester 2003; Umberson et al. 2013). Moreover, adult children are considered central figures in the social networks of their parents, providing social support and bridges to social services (Gibney et al. 2017). Children can enlarge parents' social network, build parents' social capital, and increase parents' daily communication, interaction, and social participation in their community (Gibney et al. 2017). Frequent social interaction and engagement have been proven by epidemiologists to be factors contributing to brain reserve or brain stimulation, allowing cognitive function to be maintained in old age (Fratiglioni and Wang 2007; Gow et al. 2013; Kuiper et al. 2015).

The association between parenthood and parents' health also lies in *a process of social control* (Umberson 1987). Specifically, parental role modeling of healthy eating, physical activity, and less risky health behaviors can benefit both children's and parents' health in both the short and long term (Umberson 1987). In turn, adult children, especially daughters, often play the role of primary caregiver and as such monitor parents' health behaviors, including smoking, drinking, eating, sleeping, and exercise (Umberson 1987; Umberson et al. 2010). The social control process may influence parents' health through both direct and indirect pathways. Directly, adult children can remind parents to eat healthy or avoid risk factors, help control their blood pressure, or provide interventions to help them recover from diseases (Umberson 1987; Umberson et al. 2010). Indirectly, the norms of a healthy lifestyle are likely to be internalized so that parents can actively control their own health (Umberson 1987). Good lifestyle behaviors, such as healthy eating, not smoking, good sleep quality, and regular exercise, have been well-recognized as determinants of better brain health and preserved cognitive performance for older adults (Kirk-Sanchez and McGough 2014).

The stress model emphasizes that each relationship has its dark side, including relationships between parents and children (Carr and Utz 2020; Umberson et al. 2013). Adult children may not only give parents support and care but also cause them worry, frustration, and stress, which explains why parenthood is often described as a "mixed bag" or a source of "ambivalence" (Bengtson et al. 2002; Musick, Meier and Flood 2016; Ward, Spitze and Deane 2009). Stress associated with adult children can come from many sources, such as coresidence with adult children, negative interactions with adult children (e.g., breaking up with children, mistreatment or abuse from children), having stepchildren, and death of children (Carr and Utz 2020; Pudrovska 2009). These stressors can negatively impact older parents' well-being, and the consequences are likely to be more serious if older parents are unmarried or without support within family or broader social networks (Sundström et al. 2014). Stressful events or chronic stressors can cause psychological distress (e.g., anxiety, depression) and thus increase parents' exposure to a higher risk of health problems, including cognitive decline (Thoits 1995; Rothman and Mattson 2010). Empirical studies have shown that stress directly elevates dementia risk by evoking pathophysiological metabolic effects and adverse changes in stress hormones and certain brain regions (Kuhlmann, Piel and Wolf 2005; Rothman and Mattson 2010).

EMPIRICAL EVIDENCE

Having Adult Children vs. Being Childless in Later Life

About 6.6% of U.S. adults age 55 and older have neither spouse nor biological children, and this proportion is projected to reach as high as 20% in future cohorts (Margolis and Verdery 2017). Those older adults "aging alone" who lack a close kin tie are more likely to live with loneliness and social isolation, which may increase health risks (Dykstra and Wagner 2007). Studies based on data from outside the U.S. have found that aging without children is associated with higher mortality rates, elevated risk of chronic diseases, and worse psychological well-being (e.g., Guo 2014; Huijts, Kraaykamp and Subramanian 2013; Modig et al. 2017). However, this pattern is less consistent in the U.S. studies that often indicate little difference between the well-being of parents and non-parents in later life, and some studies even suggest that childless older adults are healthier (Bures et al. 2009; Koropeckyj-Cox et al. 2007; Quashie et al. 2021; Zhang and Hayward 2001). For example, Quashie and coauthors (2021) analyzed data across 20 countries to examine the association between childlessness and health among people age 50 and older. They found that childless older adults in the U.S. had a lower risk of chronic conditions and less depression than older parents, which is consistent with evidence in other U.S. studies (e.g., Bures et al. 2009; Zhang and Hayward 2001).

Current research focusing on childlessness and cognition is limited and mainly based on European data. For example, Sundström and coauthors (2014) used population-based, longitudinal data on older adults age 65 and above in Sweden to examine how parental status is associated with risk of dementia. This study suggests that not having children was associated with incident dementia. Widowed older adults without children showed the highest risk of dementia (Sundström et al. 2014). Read and Grundy (2017) used nationally representative longitudinal data to examine the relationship between fertility history and cognition among men and women age 50 and older in England. They found that for both men and women, there was a strong association between childlessness and cognitive impairment, even adjusting for the effects of socioeconomic status, health, and social engagement factors (Read and Grundy 2017). Moreover, childless women had faster cognitive decline over the study period (Read and Grundy 2017). Similarly, a recent study using data from the UK also found that having offspring was associated with better cognitive function, such as faster response time and fewer mistakes in visual memory tasks, among both men and women (Ning et al. 2020).

Number of Children and Parental Well-being

Having a great number of children (including any type of children) is likely to be both positive and negative for parental health. On the one hand, having more children may dissolve parents' economic resources and increase perceived demands and the feeling of ambivalence in parent-child relationships (McLanahan and Adams 1987; Ward et al. 2009). On the other hand, more children may bring more support to older parents. Siblings can share the responsibility of caring, especially when some children are unavailable or unable to assist older parents (Bures et al. 2009). A majority of studies based on European countries show a J-shaped association between number of children and parental health risks: parents who have 1 to 3 children show the lowest risk of health problems, but both childlessness and high parity are associated with a higher risk of health problems, with higher parity being even more harmful than childlessness (Högnäs et al. 2017; Keenan and Grundy 2019). However, this pattern has not been consistently detected in most U.S. studies (Jacobsen et al. 2011; Spence 2008; Ward et al. 2009). For example, Ward et al. (2009) analyzed data from the National Survey of Families and Households, and they found that number of children exhibits little association with parents' psychological well-being. This non-association between number of children and parental health was also found by some studies in other countries—even European countries (Pirkle et al. 2014; Reibling and Mohring, 2018). These inconsistent findings are likely due to the fact that different studies defined parenthood differently (i.e., biological vs. social parenthood) and used various thresholds to categorize low vs. high parity.

Regarding the association between number of children and parents' cognitive health, empirical evidence is limited and predominantly based on data from European countries. For example, Ning and coauthors' (2020) study in UK found that although having offspring was associated with better cognitive health, parents with two or three children showed the largest differences compared to their childless counterparts, such as faster response time, more accurate visual memory, and significantly younger brain age (Ning et al. 2020). The authors attributed this association more to social factors than to biological processes, such as healthy lifestyle and children's support. Read and Grundy's (2017) study in England also found that compared to medium parity (2 children), older adults with low (0-1 child) and high parity (3+ children) showed poorer cognitive functioning. Although these two studies indicate an inverted U-shaped association between parity and cognitive functioning, the cutoff points for low and high parity are not quite the same, and they do not consider social parenthood (e.g., having adopted or stepchildren).

Children's Gender and Parental Well-being

Prior research on gender differences within the family is most often about the adults; the influence of children's gender on parents' health has not been a major focus of the literature (Umberson et al. 2010). However, consistent evidence shows that women are more likely to be the primary managers of family members' health care, and daughters are more likely than sons to be caregivers in the United States (Carr and Utz 2020; Horowitz 1985; Raley and Bianchi 2006). As for older parents who had dementia or cognitive impairment, a growing number of their caregivers are adult daughters, who are more likely than adult sons to assimilate information or knowledge about subjects related to health care, such as medical insurance and social services, and to provide long-term caregiving to older parents (Alzheimer's Association 2020). Most previous literature discusses how being a caregiver influences women's own health conditions, but little research provides evidence about whether women's caregiving can have an impact on the care receivers' (mostly older parents') health outcomes in the U.S. (Carr and Utz 2020). A small group of researchers in Europe looked at whether children's gender matters to older parents' well-being, but no effects were detected (Modig et al. 2017).

It has been well-recognized that good quality of care promotes the care receivers' health through good diet, regular exercise, and monitored health behaviors (i.e., reduced smoking and drinking) (Umberson 1987). Also, frequent visits or contact with children can increase interaction and communication, which potentially benefit older parents' cognitive functioning by maintaining and improving mental stimulation and brain reserves (Kuiper et al. 2015; Stern 2012; Zahodne et al. 2019). Although there is little knowledge on how children's gender can make a difference in protecting or damaging older parents' cognitive health, based on the fact that adult daughters are often the primary caregivers in families, this study expects that children's gender matters to older parents' cognition.

Stepchildren and Stepparents

Parenthood can be both biological and social. There has been a significant increase in remarriage and stepfamilies in the past four decades in the U.S. Yet stepfamilies are incompletely institutionalized, and the legal status and obligations of stepparents and stepchildren are ambiguous (Cherlin 1978; Stewart 2005; Umberson et al. 2010). Thus, it is likely that having biological children, stepchildren, or both can affect parental well-being differently in parents' later life (Pezzin, Pollack and Schone 2013). However, previous studies on parental status have often focused on biological parenthood only or simply neglected the differences between biological parenthood and step-parenthood (e.g., Modig et al. 2017; Nomaguchi 2012; Sundström et al. 2014), which may obscure real vulnerabilities among subgroups of older adults. Moreover, stepparenting can happen at any time throughout parents' life span and influences both parents and children, yet most research on stepfamilies has emphasized the consequences for children's well-being rather than parents', and the vast majority of these studies have focused on parenting minor or adolescent stepchildren (e.g., Jensen and Harris 2017). This evidence may not be applicable to explaining the effects of adult stepchildren on older parents' well-being.

Existing evidence on step-parenthood in later life is inconsistent with respect to how stepchildren influence stepparents' health outcomes. For example, using cross-sectional data from the National Survey of Families and Households (NSFH), Evenson and Simon (2005) reported that having adult stepchildren was associated with higher levels of distress, compared to being childless and having other types of children. Similarly, Pezzin and coauthors (2013) used longitudinal data from the Health and Retirement Study and found that parents with only stepchildren reported worse health outcomes than parents with only biological children. By contrast, Pudrovska's (2009) longitudinal analysis showed that having adult stepchildren is not related to the mental health of middle-aged and older parents. Bures and coauthors (2009) used HRS data from 1998 and also found that there were no differences in depression levels between childless people and parents, whether childlessness was defined biologically or socially. But their parallel analysis using data from the NSFH 1987-1988 suggested that social childlessness (the absence of any living children) was related to higher depression but not biological childlessness (having no biological children but may have stepchildren). In summary, the present study expects that step-parenthood may be related to parents' cognitive health, but the direction is not clear.

DATA AND METHODS

Data

The data for the present study were drawn from the National Health and Aging Trends Study (NHATS), 2011–2019, which is a nationally representative longitudinal sample of Medicare beneficiaries in the contiguous United States (Kasper and Freedman 2020). Detailed information on older adults' cognitive functioning and health conditions was collected in addition to demographic and other contextual data. In 2011, 8,245 respondents age 65 and older completed the initial interview (Wave 1, 71% response rate). Respondents have been reinterviewed annually to document changes over time, with the most recently released follow-up being the 2019 wave. I deleted missing values in analytical variables (3.28%). I also excluded respondents who had only one child who was under 20 years old[1] (0.01%). Therefore, the final sample included 7,498 respondents (27,243 person-year records) who had complete data on cognitive measures and other key variables from 2011 to 2019.

Measures

<u>*Outcome Variable: Cognitive Impairment*</u>

NHATS respondents completed a series of performance-based tests that measured their cognitive status. These cognitive tests evaluated three domains of cognitive functioning: memory (immediate and delayed 10-word recall, scale: 0-20, cutoff ≤ 3), orientation (reporting the date, month, year, and day of the week; naming the president and vice president, scale: 0-8, cutoff ≤ 3), and executive function (clock drawing test, scale: 0-5, cutoff ≤ 1) (Kasper and Freedman 2020). The cutoff points were defined as 1.5 standard deviations (SD) below the mean (Galvin et

[1] NHATS provides categorical age ranges of children. "Under 20" is the lowest category.

al. 2006; Kasper and Freedman 2020). The NHATS defined two types of cognitive impairment by the cutoff points: probable dementia, defined by scores below the cutoff in at least two cognition domains, and possible dementia (mild cognitive impairment), defined by scores below the cutoff in one cognition domain. Following previous literature, I defined cognitive impairment in this study by combining probable and possible dementia, which means having impairment in at least one cognition domain, while normal cognition means having impairment in no domain (Liu et al. 2019; MacNeil-Vroomen, Nagurney and Allore 2020).

For respondents who were unable to complete the cognitive tests (1.88% in raw data, 1.60% in final sample), cognitive impairment was measured by the proxy's report of a doctor's diagnosis of dementia or the proxy's responses to the Ascertain Dementia 8 (AD8), which is an 8-item measure for assessing early memory loss, temporal orientation, judgment, and function (Galvin et al. 2006; Kasper and Freedman 2020). In these cases, the respondent was categorized as having cognitive impairment if the proxy reported that the respondent had been diagnosed with dementia or if the AD8 scores met the criteria for likely dementia (scores ≥ 2).

Independent Variables

I used four variables to measure respondents' parental status in later life, including presence of adult children, number of adult children, gender of adult children, and step-parenthood. These four independent variables were derived from items in the Children and Sibling (CS) section in the Sample Person (SP) file and the Other Person (OP) file. In the Other Person (OP) file, NHATS provided categorical age ranges of other persons, including biological/adopted children and stepchildren. I excluded parents who had only one child and the only child was under 20 years old. Therefore, parents in the final sample are those who had at least one living adult child (age 20 or older), including biological/adopted children and stepchildren. The childlessness was defined by older adults who have no living child.

Presence of adult children (time-varying) was coded as a dichotomous variable, where 0 = childlessness (reference) and 1 = having at least one living adult child.

Number of children (time-varying) was coded as categorical variables, including having no living adult children (reference), one adult child, two children (at least one adult child), three children (at least one adult child), and four and more children (at least one adult child).

Children's gender (time-invariant) was coded into four categories, including having no living adult children (reference), having adult son(s) only, having adult daughter(s) only, and having both adult son(s) and adult daughter(s).

Step-parenthood (time-varying) was coded into four categories, including having no living adult children (reference), having biological/adopted children only, having stepchildren only, and having both biological/adopted and stepchildren. NHATS does not distinguish between biological and adopted children, so I categorized these two types of children together.

<u>Covariates</u>

The analysis also considered the effects of confounding factors based on the respondent's demographic characteristics. Specifically, *gender* was a dichotomous variable, coded as either female (reference) or male. *Age* was categorized into six groups: 65-69 (reference), 70-74, 75-79, 80-84, 85-89, and 90 and older. *Race/ethnicity* was self-reported and included four categories: non-Hispanic white (reference), non-Hispanic black, Hispanic, and other. *Education* included four categories: less than high school (reference), high school degree or equivalent, some college, and college graduate. *Marital status* was coded into five groups: married (reference), cohabiting, divorced, widowed, and never married. *Proxy-report* indicated whether cognitive status was reported by a proxy (0 = self-report, 1 = proxy-report). *Age, marital status,* and *proxy-report* were measured as time-varying covariates; *gender, race/ethnicity,* and *education* were time-invariant based on wave 1 data.

Analytical Strategy

To compare the risk of cognitive impairment across various parental status groups, I estimated discrete-time hazard models. Specifically, I created person-period record files and then used a logit model for the discrete-time event history analysis. A respondent contributed an observation for each wave at which they were interviewed, up to the onset of impairment or right censoring (i.e., loss to follow-up or death). The discrete-time hazard model is specified as:

$$\log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \sum_{j=1}^{9} \alpha_j \boldsymbol{D}_{ij} + \beta_1 \boldsymbol{X}_i + \beta_2 \boldsymbol{Z}_{ij}$$

where p_{ij} indicates the probability of cognitive impairment for individual i at wave j; $\sum_{j=1}^{9} \alpha_j \boldsymbol{D}_{ij}$ represents the set of multiple intercepts from 2011 to 2019, one per period; $\boldsymbol{X}_i$ is a vector of time-invariant variables; $\boldsymbol{Z}_{ij}$ is a vector of time-varying variables; and β_1 *and* β_2 are corresponding coefficient vectors. I conducted four models to estimate the relationship between four parental status variables and risk of cognitive impairment, including presence of adult children (Model 1), number of children (Model 2), gender of children (Model 3), and step-parenthood (Model 4). All covariates were included in all four models. Analyses were weighted using the wave-specific weight. I used Stata 15 to estimate the models (StataCorp 2017).

RESULTS

Table 2-1 shows the descriptive statistics of unweighted frequencies and weighted proportions for all analyzed variables for the total sample. 9.93% of respondents reported having cognitive impairment versus 90.07% who reported normal cognition. Most respondents (91.06%)

had at least one living adult child, while 8.94% of respondents were childless, without any living adult child. 11.04% of respondents had one adult child, 27.37% had two children (including at least one adult child), 23.52% had three, and 29.12% had four or more children. 58.30% of respondents had both son(s) and daughter(s), while 16.51% of respondents only had son(s), and 16.25% only had daughter(s). A majority of the respondents had biological/adopted children (77.80%), while 1.87% of respondents had stepchildren only, and 11.38% of respondents had both biological/adopted and stepchildren.

Table 2-2 presents estimated odds ratios of cognitive impairment for the four parental status variables from the discrete-time hazard models. Model 1 shows that compared with childless respondents, parents who had at least one living adult child showed a lower risk of cognitive impairment. Specifically, parents had 19% $[(1 - 0.81) \times 100\%]$ lower odds of cognitive impairment than childless older adults (OR = 0.81, $p < .05$), adjusting for the effects of all covariates. Model 2 estimates the association between the number of children and the odds of cognitive impairment. Compared to childless older adults, parents who had three children and those who had four and more children showed 22% (OR = 0.78, $p < .05$) and 19% (OR = 0.81, $p < .05$) lower odds of impairment, respectively. Yet, although the odds ratios show the same direction, parents with two and fewer children did not differ significantly from the childless older adults in terms of risk of cognitive impairment. Model 3 shows the relationships between children's gender and parents' risk of cognitive impairment, adjusting for the effects of all covariates. Compared to childless older adults, parents who had daughter(s) only showed 25% (OR = 0.75, $p < .05$) lower odds of cognitive impairment. However, parents who had sons only and those who had both sons and daughters did not show significantly lower odds of cognitive impairment than the childless (OR = 0.83, $p > .05$; OR = 0.83, $p > .05$). Model 4 estimates whether having biological versus stepchildren was related to a differential risk of cognitive impairment. Compared to childless older adults, parents who had biological/adopted children only and those who had both biological/adopted and stepchildren showed 18% and 25% lower odds of cognitive impairment, respectively, while parents who had stepchildren only did not differ significantly from the childless (OR = 0.71, p > .05).

Sensitivity Analysis

I conducted a sensitivity analysis to test the robustness of the results by excluding the left-censored observations (i.e., those with cognitive impairment at the baseline survey). Excluding the cases with cognitive impairment at baseline (n = 1,979) eliminated the influence of the baseline association between parental status variables and parents' cognition. The results (shown in Table 2-3) show the same patterns, with the same direction of odds ratios as reported in Table 2-2, but some of the associations were not statistically significant, which was likely due to the reduced sample size. Notably, Model 2 demonstrates robust results, indicating that parents who had three children (with at least one adult child) showed 23% lower odds of cognitive impairment than childless older adults. Model 3 also suggests robust results, indicating that parents who only had daughter(s) showed a 28% lower risk of cognitive impairment than childless older adults.

DISCUSSION

Using data from the National Health and Aging Trends Study (NHATS) 2011-2019, this study examines whether parental status is related to risk of cognitive impairment among older adults. I found that the presence of adult children (i.e., having at least one living adult child) was associated with a lower risk of cognitive impairment than childlessness for older adults. Older parents who had three and more children displayed a significantly lower risk of cognitive impairment than the childless, while parents who had two and fewer kids did not. Moreover, compared to childless older adults, parents who had adult daughter(s) showed a lower risk of cognitive impairment, but having only adult son(s) or having both son(s) and daughter(s) did not significantly reduce the risk. Last, compared to childlessness, the presence of biological/adopted adult children was associated with a lower risk of cognitive impairment, but having only stepchildren was not.

This study indicates that being childless in later life makes older adults more vulnerable to the risk of cognitive impairment than parents with living adult children. This finding is consistent with previous evidence of a health disadvantage among the childlessness (Koropeckyj-Cox et al. 2007; Modig et al. 2017; Pudrovska 2009). Childless older adults are often regarded as the most unsupported and socially isolated population because they are more likely to experience loneliness, elder abuse, and inability to access formal care (Carr and Utz 2020; Xu et al. 2018). Scientific evidence has demonstrated that loneliness and isolation significantly increase older people's risk of cognitive decline (Kuiper et al. 2015; Maharani, Pendleton and Leroi 2019). By contrast, the presence of adult children benefits older parents' cognitive functioning (Ning et al. 2020; Read and Grundy 2017; Sundström et al. 2014). Although previous evidence was mainly based on European data, this study suggests that the same pattern is also found in the U.S. The cognitive advantage among older parents may be due to children's support and social control processes. Specifically, adult children often provide parents with both social and emotional support (Carr and Utz 2020; Umberson et al. 2010). Children broaden parents' kinship and networks and provide parents with caring, love, and intimacy. Frequent contact or visits and good communication or interaction with children and grandchildren are likely to increase parents' feeling of connectedness and reduce loneliness, which are factors contributing to brain reserve and stimulation, allowing cognitive function to be maintained in old age (Fratiglioni and Wang 2007; Gow et al. 2013; Kuiper et al. 2015). Moreover, adult children are often the primary caregivers for older parents and help monitor parents' health behaviors, enforcing reduced smoking and drinking and regular meals and exercise, which can reduce parents' exposure to health risk factors (Carr and Utz 2020).

This study further indicates that parents who have three and more adult children showed a lower risk of cognitive impairment than the childless, while those having two and fewer children do not. This finding is inconsistent with previous parity studies finding a J-shaped or U-shaped relationship between parity and parents' health problems, including risk of cognitive impairment (Högnäs et al. 2017; Keenan and Grundy 2019; Ning et al. 2020; Read and Grundy 2017). This may be largely because the present study included both biological and social parents and focused on the aging population above 65 years old. Having more adult children in later life usually means more support available to older parents, and adult children can share caregiving responsibility with siblings. Adult children are mostly nonresidential children and often have multiple roles as caregivers to both parents and their own children, making it likely that they are not always available or able to assist older parents (Bures et al. 2009). A greater number of children may reduce this unavailability of support to parents. Moreover, this finding could also result from a selection effect, if parents who were able to have more kids, both social and biological, are those who were healthier or who had better cognitive status. Such parents are more likely to be selected into parenthood and maintain a larger family network.

Another important finding of this study is the positive effects of having adult daughter(s) on parent's cognitive health. Previous research studying gender differences within the family often focused on parents' gender rather than children's gender, and evidence is rare with respect to how children's gender influences parents' cognitive ability in later life. But what has been well-recognized is that caregiving, like other types of domestic labor, is often regarded as women's work (Carr and Utz 2020). Women are more likely to be the primary managers of family members' health care, and daughters are more likely than sons to provide care to their older parents, especially parents with cognitive impairment (Alzheimer's Association 2020; Horowitz 1985; Raley and Bianchi 2006). Moreover, women often play the role of "kin keeper," connecting family members and extended social networks. Having at least one daughter increases the chances that an older parent has telephone communication and visits from his/her children, while having only sons or all sons seems to be "no substitute for daughters" (Raley and Bianchi 2006). Therefore, frequent contact, communication, and good caregiving are possible explanations for the association between having adult daughters and parents' lower risk of cognitive impairment. However, it is not clear why parents with both sons and daughters did not show a significantly lower risk of cognitive impairment than the childless. In future studies, it would be worth exploring how the gender composition of sibships influences gendered caregiving to parents and further affects parents' well-being in later life.

Step-parenthood and its impact on parents' well-being has not been fully examined in prior literature, and the existing evidence is mixed (Bures et al. 2009; Ward et al. 2009). This study suggests that compared to childlessness, having only stepchildren did not benefit parents' cognitive health, but the presence of biological/adopted children does, which is consistent with prior evidence showing the health disadvantage among parents with stepchildren only (Pezzin et al. 2013). Step-parenthood may increase parents' psychological distress (e.g., worry, stress, anxiety), which is often caused by relationship strain with stepchildren or conflict with a remarried spouse (Stewart 2005; Ward et al. 2009). Cherlin (1978) argued that stepfamilies are incompletely institutionalized because of their ambiguous boundaries and a lack of clarity of obligation or expectation. It is likely that adult stepchildren feel less obligated to take care of their stepparents, especially for cognitively impaired parents who need long-term, intensive care. Less contact/communication and support from stepchildren as well as psychological distress associated with step-parenthood may increase parents' social isolation and further trigger the onset or progression of cognitive impairment. However, this finding should be interpreted carefully because my sample includes a very small number of stepparents who have stepchildren only (1.87%). The direction of the coefficient (OR = 0.71, $p > .05$) is consistent with other categories, so the lack of significance is probably due to the small sample size rather than substantive difference. Indeed, some studies have argued that the negative consequences of step-parenthood decline over time (Stewart 2005). Compared to step-parenthood in early or mid-life, older stepparents and adult stepchildren may have more resilience and benefit from a longer time for relationship adjustment (Stewart 2005; Umberson et al. 2010).

This study is not without limitations. First, there is likely a selection effect in the analysis. For example, people with better cognitive status are more likely to be selected into parenthood or into parenting more children. Considering the association between childlessness and mortality, older adults who are childless are more likely to be lost to follow-up (Modig et al. 2017). Thus, the childless older adults in the final sample were "survivors" with the resilience to deal with the negative impact of being childless, and the analysis may be conservative in evaluating the association between parental status and cognition. Second, this study did not find any significant gender differences among the older adults, although previous literature suggests that parenthood may impact men and women differently. Future research can use different datasets to examine whether parental status in later life shows gender variations in its effects on cognitive health.

Third, because the measures of cognitive impairment are based on performance-based cognitive tests and proxy reports rather than clinical diagnoses, the issue of potential misclassification cannot be ignored. Fourth, the NHATS only provides a derived variable for stepchildren, without information on other types of children (e.g., foster), and is unable to distinguish between biological and adopted children. Last, the pathways to childlessness in later life can be very diverse (Dykstra and Wagner 2007). For example, there are differences between the voluntarily and involuntarily childless, and between the lifelong childless and those who have outlived children, which lead to various experiences among non-parents. Future studies can use more detailed measures to describe different pathways to childlessness and how they influence older adults' cognitive health.

CONCLUSION

People are living longer today, and the parenthood experience is becoming more complex in the U.S. Though adult children are the most important figures in parents' social connection and essential caregivers for older parents, their influence on parents' cognitive health has not been fully understood. This is one of the first studies focusing on the connection between parental status in later life and its impact on parents' cognitive health. The study adopts a life course perspective by identifying comprehensive measures of parental status, including not only the presence of children but also the number of children, children's gender, and the presence of stepchildren. The results suggest that being childless and having stepchildren only are potential risk factors for cognitive impairment, while having more adult children and especially having adult daughter(s) are possible protective factors for parents' cognitive health. This study highlights the importance of adult children as resources of support and caring that can bolster older parents' cognitive health. The findings can help to identify the most vulnerable subpopulations among aging adults so that social workers, medical practitioners, and policy makers can design effective interventions and strategies to protect cognitive functioning for those "at risk" older adults.

CHAPTER 3

PARENT-CHILD RELATIONSHIP QUALITY AND ITS IMPACT ON PARENTS' COGNITIVE FUNCTIONING AT LATER LIFE

INTRODUCTION

Parent-child relationships, as one of the most important family relationships, can significantly influence parents' health outcomes and quality of life (Fingerman et al. 2012; Ha 2010; Koropeckyj-Cox 2002; Pillemer and Suitor 2002; Reczek and Zhang 2016). For older parents, children are typically their primary caregivers and essential sources of social connection and emotional support (Carr and Urz 2020; Umberson et al. 2010). However, prior literature often described parenthood as a "mixed" experience including both benefits and costs, and the parent-child connection often created ambivalence which can have a mixed impact on parents' well-being (Nomaguchi and Milkie 2020; Umberson et al. 2010). It has been well-recognized that relationship closeness and children's support can promote parents' health, whereas relationship conflict and strain with children can damage parents' health (Koropeckyj-Cox 2002; Reczek and Zhang, 2016; Knoester 2003; Ha 2009). Yet, despite the fact that various parental health outcomes have been examined, the association between intergenerational relationships and parents' cognitive health is not fully understood.

Cognitive impairment has emerged as an increasing public health concern because it is associated with an increased risk of developing Alzheimer's or other types of dementia (Alzheimer's Association 2020). As the U.S. population ages, the prevalence of cognitive impairment is expected to grow, placing an increasing burden on their families, as well as long-term care systems (Fisher et al. 2011; Kuiper et al. 2015). Recent effort made by social scientists found that involvement in social relationships, such as being married, having a larger network, and participation in social activities, can boost older adults' cognitive health (Liu et al. 2019; Zahodne et al. 2019), but the effects of intergenerational connection, one of the most important social relationships, remain unknown. Furthermore, existing literature has predominantly examined the structure of parental status but neglected the quality of intergenerational relationships and its impact on health outcomes, whereas relationship quality could be an equally or even more important factor relating to parents' well-being (Reczek and Zhang 2016).

To address these gaps of knowledge, this study analyzes nationally longitudinal data from the Health and Retirement Study (2006-2016). This chapter aims (1) to explore multiple dimensions of the relationship quality between older parents and children, (2) to examine whether the quality of the parent-child relationship can predict older parents' cognition trajectories over time, and (3) to explore whether there are gender differences between fathers and mothers in these patterns.

THEORETICAL FRAMEWORKS

There are three major frameworks: *the life course theory, intergenerational ambivalence theory, and the stress model*, that can guide the linkage between intergenerational relationships and parents' cognitive health. First, *the life course theory* emphasizes that parent-child relationship as one of the most important life contexts can shape parents' well-being (Elder 1994, 1995; Umberson et al. 2013). The "linked lives" between parents and children indicate parent-child interaction is reciprocal and interwoven, and its impact on parental well-being can be cumulative throughout parents' life course (Bengtson et al. 2012; Elder 1994; Umberson et al. 2010). Cognitive function can be influenced by harmful exposures later in life and can possibly decline into Alzheimer's disease or other types of dementia (Glymour and Manly 2008).

Relationship conflict and strain between older parents and their children are potential risk factors to increase this "harmful exposure". However, studies in this area had often emphasized the effect of parental status (i.e., presence of children, number of children) on parents' cognitive functioning but neglected the impact of relationship quality (e.g., Guo 2014; Huijts et al. 2013; Modig et al. 2017), leading to less powerful explanations on why and how parenthood in later life can link to cognitive health or not. Moreover, as a fundamental life context, gender often determines both parenting experience and risk of cognitive impairment, but there is a lack of attention paid on parents' gender variations in this area. Parent-child relationships can vary by parents' gender, and the magnitude of impact on cognition was expected to be different for older fathers and older mothers (Carr and Utz 2020). In short, a gendered life course perspective guides the present study to explore the quality of the "linked lives" between older parents and children and its impact on both fathers' and mothers' cognition.

The second major framework, *intergenerational ambivalence theory*, demonstrates that the parent-child relationship can give both parents and children a mixed feeling, including both benefits and costs (Pillemer and Suitor 2002; Silverstein and Giarrusso 2010; Ward et al. 2009). Parenthood scholars also conceptualize this mixed feeling using a *demands–rewards perspective* (Nomaguchi and Milkie 2003; Nomaguchi and Milkie 2020), indicating parenting was a "mixed bag" with both rewarding experiences and frustrating challenges (Musick et al. 2016; Nomaguchi and Milkie 2020). This theory explains why some empirical evidence failed to find an association between the presence of children and parents' well-being. That is likely because the negative interaction may cancel out the positive effects of parenting on parental well-being (Bures et al. 2009; Koropeckyj-Cox et al. 2007). Moreover, for parents who have multiple children, parental well-being can be both positively and negatively influenced by some kids' life success and some kids' life problems (Birditt, Fingerman and Zarit 2010; Fingerman et al. 2020; Kiecolt, Blieszner and Savla 2011; Ward et al. 2009). For older parents who experience physical declines and need intensive caregiving from adult children, children's ambivalence towards older parents can influence how children provide care and support to older parents and then affect parents' health outcomes and quality of life (Willson, Shuey and Elder 2003). In summary, the ambivalence perspective emphasizes a mutual, mixed feeling between older parents and children. Therefore, both positive and negative feelings are potentially linked to parents' well-being.

Last, *the stress model* emphasizes that relationship strain with children is likely to predict a higher risk of cognitive decline for aging parents (Fratiglioni et al. 2000; Li et al. 2020; Zahodne et al. 2019). Previous literature has signified that lack of support or care, relationship conflict, and negative interaction with family members can increase people's life stress, leading to a higher risk of health problems (Liu and Waite 2014; Thoits 2010; Reczek and Zhang 2016). Negative interaction with children, such as having demanding children, emotional abuse from children, breaking up with children, are stressors that can curtail parents' time and money to take care of themselves, which is likely to increase the development of parents' sleep problems, chronic diseases, and psychological distress (Milkie et al. 2008; Nomaguchi 2012; Umberson et al. 2010). Moreover, increased relationship conflict can stimulate parents' stress hormones (e.g., catecholamines, cortisol), impair the immune system, and evoke physical responses, which may have a long-term negative impact on brain reserve and cognition function (Kuhlmann et al., 2005; Oei et al. 2007). The negative interaction with children may also have a *spillover effect* or an effect of *stress proliferation*, resulting in additional or even greater life strains, such as economic hardships, social isolation, loss of or conflict with larger family network (e.g., grandchildren, relatives) (Nomuguchi and Milkie 2020; Pearlin and Bierman 2013; Thoits 2010).

Therefore, relationship strain with children is a potential source of life stress that can be pathogenic and raise parents' vulnerability to cognitive decline (Rothman and Mattson 2010; Johansson et al. 2013).

EMPIRICAL EVIDENCE: PARENT-CHILD RELATIONSHIP AND PARENTS' COGNITIVE FUNCTIONING

Research in the past two decades has shown the quality of intergenerational relationship matters to older parents' health, but a vast majority of the literature in this area focused on parents' psychological well-being (e.g., Ha 2010; Koropeckyj-Cox 2002; Knoester 2003; Milkie et al. 2008; Reczek and Zhang 2016). For example, Reczek and Zhang (2016) used four waves of national data from the Americans' Changing Lives (ACL) (N = 1,692) to test whether parent-child relationships shape mid- or later-life parents' psychological distress. They found that relationship dissatisfaction with children predicted the change in parents' distress over time. Another two studies based on the U.S. population also found that positive support from children was associated with fewer depression symptoms, while negative treatment by adult children was related to increased depression and anger (Ha 2010; Milkie et al. 2008). Although these studies did not provide direct evidence between intergenerational relationships and cognition, they indicated potential mechanisms that can connect relationship quality and risk of cognitive impairment because psychological distress is strongly associated with increased risk of dementia and cognitive deficits (Rothman and Mattson 2010).

Literature regarding the effects of the parent-child relationship on parents' cognition is limited, especially a lack of focusing on the U.S. population. A study by Zahodne and coauthors (2019) analyzed longitudinal data from the Health and Retirement Study (N = 10,390) to test how both structure and quality of social relationships had an impact on older adults' memory. They found that having more frequent contact with children and reporting less strain with children were associated with better initial memory levels but not subsequent memory decline (Zahodne et al., 2019). A small group of empirical research outside the U.S. shows similar patterns. For example, Fratiglioni et al. (2000) used a longitudinal population-based study in Sweden, focusing on older adults aged 75 or above in 1987 to examine how having children, frequency of contacts with children, and satisfaction with the contacts can influence parents' incidence of dementia. They found that having children with frequent but unsatisfying contact was related to an increased dementia incidence (Fratiglioni et al., 2000). A Japanese national survey of older people aged 60 and above examined how social support and negative interaction were associated with cognitive impairment (Okabayashi et al. 2004). They found a significant association between greater support from children and reduced risk of cognitive impairment among older parents who did not have spouses (Okabayashi et al. 2004). This association was also found in some recent cohorts of older adults. For example, Li and coauthors (2020) classified types of relationships between older adults and their children using population-based data of older Chinese immigrants in Chicago from 2011 to 2013. They found that absence of intergenerational solidarity and presence of relationship conflict were associated with poorer cognitive performance than ambivalent typology (i.e., relationship including both solidarity and conflict) (Li et al. 2020). Yin and coauthors (2020) used longitudinal data from 2005 to 2014 to examine how social support relates to the incidence of cognitive impairment. The analysis also indicated that children's visits were significantly associated with a lower incidence of cognitive impairment in Chinese older adults, controlling for the effects of other types of social support (Yin et al. 2020). Although empirical study in the U.S. is limited, consistent findings outside the U.S. suggest that frequent contact and greater support from children benefit parents' cognitive health while relationship strain damages it. Therefore, I hypothesize that, *H1. Frequent contact and positive relationship with children are associated with better cognitive functioning, while relationship strain with children is associated with lower cognitive functioning for both older fathers and older mothers.*

GENDER VARIATIONS: DIFFERENCES BETWEEN FATHERS AND MOTHERS

The effect of intergenerational relationships on parents' cognitive health is likely to show gender differences between fathers and mothers, despite prior evidence that barely explores this. Some scholars argue that relationships with children influence mothers' well-being more profoundly than fathers (Lendon, Silverstein and Giarrusso 2014; Pillemer and Suitor 2002). This is because mothers typically play the role of the "kin-keepers" with stronger obligations to maintain family ties, connecting the father with children and extended family network (Silverstein & Bengtson, 1997). Previous literature shows a consistent gender pattern in parental involvement, suggesting that mothers are more likely than fathers to spend social time with children and being more emotionally involved in children's lives (Bianchi, Robinson & Milkie, 2006; Kalmijn 2007; Nomaguchi 2012; Reczek and Zhang 2016). Fathers often obtain support from children in part through the kin-keeping role of mothers (Kalmijn 2007). Therefore, mothers are more likely to experience relationship ambivalence than fathers because the "kin-keeper" role may increase both benefits and costs for mothers (Pillemer and Suitor 2002). This greater ambivalence is likely to make mothers' well-being become more sensitive to the quality of intergenerational relationships than fathers.

The gender variations have been often examined in the studies investigating the association between intergenerational relationships and parents' psychological well-being (Milkie 2008; Reczek and Zhang 2016; Ward et al. 2009). Consistent findings focusing on the U.S. older parents with adult children indicated that the effects of intergenerational relationship on parents' psychological well-being was stronger for mothers than fathers (Milkie 2008; Reczek and Zhang 2016; Ward et al. 2009). For example, Reczek and Zhang (2016) found that compared to older fathers, older mothers received more support from adult children, had more contact with adult children, and had a lower level of dissatisfaction with children. Similarly, Ward and coauthors (2009) found that older mothers experienced more positive relations with adult children without experiencing more negative relations than fathers. Milkie (2008) also found that the effects of negative treatment by adult children were related to increased anger for older mothers but not older fathers. In short, these findings reflect either the benefits or the costs of intergenerational relationships can be stronger for mothers than fathers. Despite the fact that little is known whether this gender variation can be extended to cognitive health, according to the existing evidence from psychological well-being research, I expect that,

H2: The association between parent-child relationship quality and parents' cognitive functioning is stronger for older mothers than older fathers.

DATA AND METHODS

Data

Data were drawn from the Health and Retirement Study (HRS, 2006-2016), a national representative, longitudinal panel data, conducted by the Institute for Social Research at the University of Michigan. The HRS data are collected every two years with samples of Americans over age 50 since 1992 (Sonnega and Weir 2014). In 2006, a random half of the sample was selected to participate in a psychosocial and lifestyle questionnaire, and the other half was selected to participate in 2008. This questionnaire includes information of respondent's assessment evaluations of quality of social ties, in which respondents assessed positive and negative support received from spouse/children/family/friends as well as contact frequency with family/children/friends (Smith et al. 2017). This longitudinal data from the psychosocial questionnaire is available at four-year intervals. Specifically, the participants in 2006 were reinterviewed in 2010 and 2014, while the 2008 participants were reinterviewed in 2012 and 2016. In this study, these two groups of the non-overlapping sample who completed the psychosocial questionnaire in 2006 or 2008 were combined to form a baseline time point. Hence, there are three time points of relationship quality in total (i.e., time 1 = 2006/08, time 2 = 2010/12, and time 3 = 2014/16). The cognitive data were biennially collected, resulting in five time points (i.e., time 1 = 2008, time 2 = 2010, time 3 = 2012, time 4 = 2014, and time 5 = 2016) in the combined sample.

In the analysis, I excluded respondents who were younger than 50 at the baseline and people who did not have children in each wave. I further excluded missing values in binary or categorical covariates, such as education, race/ethnicity, and parents' marital status at baseline. The final analytic sample included 13,386 respondents (5,474 fathers and 7,912 mothers) who had at least one child (i.e., biological, step, and other types of children). In the final sample, 93.03% had available cognitive data at Time 1 (2008), 82.71% had available cognitive data at Time 2 (2010). 76.40% had available cognitive data at Time 3 (2012), 68.18% had available cognitive data at Time 4 (2014), and 58.28% had available cognitive data at Time 5 (2016). Missing values in relationship quality and cognitive scores were handled by a Full Information Maximum Likelihood (FIML) estimation approach in Mplus (Muthén and Muthén 1998-2015).

Measures

<u>*Parents' cognition functioning.*</u>

HRS assesses cognition using the modified version of Telephone Interview for Cognitive Status (TICS). This test includes the following cognitive items: immediate and delayed recall of a list of 10 words (1 point for each), five trials of serial 7s (i.e., subtract 7 from 100, and continue subtracting 7 from each subsequent number for a total of five trials, 1 point for each trial), and backward counting (2 points). The final score ranges from 0 to 27, in which a higher score suggests better cognitive functioning (Crimmins, Saito and Kim 2016; Liu et al. 2019).

Intergenerational relationship quality.

Measures of relationship quality between parents and children include three dimensions: contact frequency with children, relationship support, and relationship strain received from children.

Contact frequency with children was assessed with two items: (1) "How often do you meet up (include both arranged and chance meetings) with your children?" (2) "How often do you speak on the phone with your children?" Items were rated on a 6-point scale ranging from 1 = three or more times a week to 6 = less than once a year or never. Items were reversely coded so that higher scores correspond to greater contact frequency with children. The final number of contact frequency was quantified as the mean of the two items.

Relationship support from children was assessed with three items: (1) "How much do children really understand the way you feel about things?" (2) "How much can you rely on children if you have a serious problem?" and (3) "How much can you open up to children if you need to talk about your worries?" Items of relationship support were rated on a 4-point scale ranging from 1 = a lot to 4 = not at all. Items were reversely coded so that higher scores correspond to greater relationship support. The final support score was quantified as the mean of the three items (Zahodne et al. 2019). The Cronbach's alpha of the reliability test was greater than 0.82, indicating a sufficient level of internal consistency.

Relationship strain was assessed with four items: (1) "How often do children make too many demands on you?" (2) "How often do children criticize you?" (3) "How much do children let you down when you are counting on them?" and (4) "How much do children get on your nerves?" Items of both relationship support and strain were rated on a 4-point scale ranging from 1 = a lot to 4 = not at all. Items were reversely coded so that higher scores correspond to greater relationship strain. The final strain score was quantified as the mean of the four items (Zahodne et al. 2019). The Cronbach's alpha of the reliability test was greater than 0.77, indicating a sufficient level of internal consistency.

Covariates

I controlled for sociodemographic information at the baseline wave (2006). *Gender* was a dichotomous variable with men/father as the reference category (0 = male; 1 = female). *Age* at baseline (in years) was a continuous variable and centered at mean in the final analysis. *Race/ethnicity* was coded into four categories: non-Hispanic white (reference), non-Hispanic black, Hispanic, and non-Hispanic other. *Education* was coded into four categories: less than high school (reference), high school graduate, some college, and college graduate or above. *Parents' marital status* was a dichotomous variable with married/partnered as reference category and unmarried (i.e., divorced, widowed, and never married). Baseline assessment wave was also included as a dichotomous variable with starting the psychosocial questionnaire interview since 2006 as the reference category (0 = 2006; 1 = 2008).

Analytical Strategy

I tested the associations between intergenerational relationships and cognitive trajectories using latent growth curve models (LGCM) with maximum likelihood estimation. Models estimate initial level (latent intercept) and subsequent rate of change (latent slope) for both the relationship quality and cognitive scores over the study period. Because the initial level of relationship quality and the subsequent changes vary by individuals over time, I used the parallel LGCM to estimate whether the intercept of relationship quality can predict both the intercept of cognition and the slope of cognition and whether the slope of relationship quality can predict the slope of cognition. The equations of the parallel LGCM can be specified as:

$$Y_{it} = \pi_{0i} + \pi_{1i}T_{it} + \varepsilon_{it}$$

$$\pi_{0i} = \alpha_0 + \beta_{00}\theta_{0i} + X'A_0 + \delta_{0i}$$

$$\pi_{1i} = \alpha_1 + \beta_{10}\theta_{0i} + \beta_{11}\theta_{1i} + X'A_1 + \delta_{1i}$$

where Y_{it} denotes the *i*th individual's cognitive function at time *t*. π_{0i} and π_{1i} are the latent intercept and latent slope of the cognitive trajectories for the *i*th individual across waves. T_{it} is the number of years since the baseline. β_{00}, β_{10}, and β_{11} are parameters describing the effects of relationship quality trajectories on the cognitive trajectories. θ_{0i} and θ_{1i} are the latent intercept and latent slope of relationship quality trajectories for the *i*th individual across waves. X is the vector of covariates, and A_0 and A_1 are vectors of corresponding coefficients. ε_{it}, δ_{0i}, and δ_{1i} represent residual terms. Figure 3-1 provided a graphical depiction of a parallel latent growth curve model. Last, based on the LGCM, I used multiple group analysis to examine if the association between intergenerational relationships and cognition varies by gender. Model fit was evaluated with three commonly used indices: comparative fit index (CFI), Tucker-Lewis index (TLI), and root-mean-square error of approximation (RMSEA). I used Mplus 8.3 to estimate the growth curve models (Muthén & Muthén 1998-2015).

RESULTS

Table 3-1 displays the descriptive statistics of all analytical variables in the total sample and samples by gender. Generally, respondents' cognitive functioning declined over the study period. Mothers were more likely to show significantly better cognitive functioning at each time point than fathers. For both fathers and mothers, the contact frequency with children reduced, the positive relationship with children slightly increased, and the negative relationship slightly decreased over time. Compared to fathers, mothers contacted with children more frequently, and mothers reported both greater relationship support and greater relationship strain (except 2014/2016) received from children. Moreover, mothers were more likely to be younger, non-Hispanic black, high school graduates, and unmarried, while fathers were more likely to be older, non-Hispanic white, college graduates, and married or partnered.

Table 3-2 shows the results from the latent growth curve models predicting initial levels of cognition (latent intercept) and the rate of change in cognition (latent slope). Panel A, B, and C present how contact frequency, relationship support, and relationship strain with children predicted the parents' cognitive trajectories, respectively. The means and variances of growth parameter and model fit indexes were also shown at the bottom of the model panels. Panel A in Table 3-2 suggests that adjusting the effects of covariates, higher initial levels of contract frequency with children were associated with higher initial levels of cognitive function for older parents ($\beta_{00} = 0.308$, $p < .001$). The rate of change in contact frequency was associated with the rate of change in parents' cognition ($\beta_{11} = 0.615$, $p < .01$). Panel B indicates that high initial levels of relationship support from children were associated with higher initial levels of cognitive function for older parents ($\beta_{00} = 0.490$, $p < .001$), but neither the initial level nor the rate of change of relationship support was associated with the rate of change in parents' cognition. Panel C suggests that high initial levels of relationship strain with children were associated with lower initial levels of cognitive function for older parents ($\beta_{00} = -0.796$, $p < .001$), and the rate of change in relationship strain was associated with the rate of change in parents' cognition (β_{11} = -

1.061, $p < .01$). In summary, results in Table 3-2 indicate that initial levels of contact frequency and relationship support were positively associated with parents' initial levels of cognition, while initial levels of relationship strain were negatively associated with initial levels of cognition. Moreover, a faster increase in contact frequency improved a greater increase in cognition, while a faster worsening relationship with children triggered a faster decline in parents' cognition.

Table 3-3 presents the results from multiple group analysis by parents' gender. Like the main results of total sample in Table 3-2, the results by gender suggest that for both mothers and fathers, the higher initial levels of contact frequency and relationship support were associated with higher initial levels of cognitive function (Panel A: $\beta_{00} = 0.294$, $p < .001$ for men, $\beta_{00} = 0.314$, $p < .001$ for women; Panel B: $\beta_{00} = 0.400$, $p < .001$ for men, $\beta_{00} = 0.548$, $p < .001$ for women) while the higher initial levels of relationship strain were associated with lower initial levels of cognition (Panel C: $\beta_{00} = -0.777$, $p < .001$ for men, $\beta_{00} = -0.841$, $p < .001$ for women). However, the rate of change in contact frequency and relationship strain were only associated with mothers' cognitive change rate, not fathers. Specifically, a faster increase in contact frequency improved greater increase in cognition for mothers (Panel A: $\beta_{11} = 0.484$, $p < .05$), and a faster worsening relationship with children was associated with a faster decline in mothers' cognition (Panel C: $\beta_{11} = -1.040$, $p < .05$). Also, mothers' initial levels of relationship support from children were negatively associated with the rate of change in cognition (Panel B: $\beta_{10} = -0.031$, $p < .05$). The rate of change in relationship support was not associated with change in both mothers' and fathers' cognition (Panel B).

DISCUSSION

The "linked lives" between parents and children significantly shape parents' life contexts and play an important role in affecting parents' health and quality of life (Bengtson et al. 2012;

Carr and Utz 2020; Elder 1994; Umberson et al. 2010). This study suggests that this interwoven relationship can influence parents' cognitive health as well. The analysis from a national sample of older adults over ten years indicates that initial levels of greater contact frequency with children and relationship support from children were associated with higher initial cognitive functioning, while initial levels of greater relationship strain with children were associated with lower initial cognitive functioning. Moreover, an increase in contact frequency improved a greater increase in cognition, while a worsening relationship with children triggered a faster decline in parents' cognition. These associations were more pronounced for older mothers than older fathers. The findings are generally consistent with existing evidence showing the connection between intergenerational relationship and parents' cognitive functioning (Fratiglioni et al. 2000; Li et al. 2020; Okabayashi et al. 2004; Yin et al. 2020; Zahodne et al. 2019).

First, this study found that frequent contact with children was not only associated with higher cognitive levels but also slower subsequent cognitive decline. Keeping frequent contact with children can increase parents' daily communication, language ability, and memory, which are likely to increase neural plasticity, promote mental stimulation and strengthen cognitive reserve (Kuiper et al. 2015; Giles et al. 2012; Zahodne et al. 2019). Second, relationship support from children was associated with a high initial level of cognition for older parents. Emotional support often increases parents' life satisfaction and can play the role of stress buffer by diminishing the negative effects of life strains (e.g., financial loss, death of spouse, health decline) on parents' psychological well-being (Knoester 2003; Umberson et al. 2013). Considering the stronger association between psychological distress (e.g., depression, loneliness) and risk of cognitive impairment (Kuhlmann et al. 2005), children's support may reduce such harmful exposure to psychological distress so that it protects cognitive health. However, increased relationship support did not slow the cognitive decline over time, which is consistent with prior evidence showing a lack of association between quality of social relations and subsequent rates of cognitive functioning (Zahodne et al. 2019). This is likely because of a short follow-up period and relatively young age of the older sample, also because of a stronger effect of relationship strain on cognition. Indeed, relationship strain with children was not only associated with worse initial cognitive levels but also predicted a faster decline in cognition over time. This finding resonates with the stress model in explaining the relationship strain and higher risk of cognitive impairment. Stress can negatively influence cognitive ability because it stimulates parents' stress hormones (e.g., catecholamines, cortisol), impair the immune system, and evoke physical responses, which may impair parents' brain reserve and cognition function (Kuhlmann et al. 2005; Oei et al. 2007). Moreover, the negative consequences of relationship strain and a lack of positive effect of relationship support on the rate of change in cognition is also consistent with some parenthood ambivalence literature. For example, Fingerman and coauthors (2012) found that parents experienced poorer well-being when at least one adult child had life problems even if the other kids were faring well. For older parents who have multiple children, they often experience both positive and negative interaction with children, and the negative effects of relationship strain are likely to cancel out or even exceed the positive effects of children's support (Fingerman et al. 2012).

This study also found that the effect of intergenerational relationship quality on cognitive functioning was stronger for older mothers than older fathers, which is consistent with prior parenthood studies showing mothers' well-being is more sensitive to the parent-child relationship quality (Lendon et al. 2014; Milkie 2008; Pillemer and Suitor 2002; Reczek and Zhang 2016; Ward et al. 2009). First, consistent with prior evidence that normatively, women are more likely than men to be involved in parental roles and have more contact with adult children (Bianchi et al. 2006; Carr and Utz 2020; Kalmijn 2007; Reczek and Zhang 2016), this study also found that older mothers contacted with their children more frequently than older fathers' at each time point, and the frequency contact predicted a slower rate of cognitive decline only for older mothers. Second, frequent contact or a closer relationship with children often leads to a stronger ambivalence for mothers that both positive and negative effects on mothers' well-being could be upgraded (Pillemer and Suitor 2002). This study indeed found that older mothers reported both greater relationship support and strain with children than older fathers, and relationship strain was associated with a faster cognitive decline for older mothers, not older fathers. However, it is puzzling that relationship support negatively affected older mothers' cognitive trajectories. This is inconsistent with existing evidence and broad literature in parenthood. A possible explanation lies in the measure of relationship support was from parents' subjective evaluation that may not accurately quantify the care and support from children (e.g., time of visit, amount of economic support). It is likely that the deviations between parents' expected support and actual support received from children influence parents' well-being. Mothers are more likely to expect a greater support and thus experience greater deviations.

This study has several limitations. First, the analysis was constrained by the way relationship quality variables were collected. Relationship quality measures were collected every four years, but cognitive measures were collected every two years. Hence, this study only had three time points of relationship quality with children, which is a short observation period to capture the changes in relationship quality. Future studies using longer follow-up observations can yield greater changes so that they reveal a more precise estimation of the association. Second, the sample in this study is likely to be selective as childless older parents were excluded.

Those who were healthier with a lower risk of cognitive impairment are more likely to be selected into parenthood or maintain good relationships with children. Hence, the findings may be conservative in estimating the potential negative effects of relationship strains between parents and children. Third, this study did not distinguish types of children considering the small sample size of non-biological children. However, it is likely that parent-child relationship quality varies by the types of children and influences both the positive and negative effects on parents' cognitive heath (Carr and Utz 2020; Pezzin et al. 2013). Last, measures of contact frequency are unable to capture new communication technologies, such as text messages and social media. Although the HRS questionnaire added a question of contact frequency on social media since 2016, this question was not included in previous waves. Future research should consider new technologies of communication to measure contact frequency, especially when focusing on recent cohorts.

CONCLUSION

Prior literature has suggested that relationship quality between parents and children related to parental well-being (Fingerman et al. 2012; Ha 2010; Koropeckyj-Cox 2002; Reczek and Zhang 2016). This study extends the literature by demonstrating that contact frequency, relationship support, and relationship strain with children were associated with the initial cognitive levels among older parents. Moreover, parent-child relationship quality also predicted cognitive trajectories for older mothers but not for older fathers. This study can contribute to an understanding of intergenerational relationship quality and successful aging, suggesting that increasing contact and reducing relationship strain may protect older parents' cognitive health in later life, especially for older mothers. Future studies can use more detailed measures of relationship quality between parents and children and explore specific mechanisms between intergenerational relationships and cognitive health.

CHAPTER 4

FERTILITY HISTORY AND RISK OF COGNITIVE IMPAIRMENT AMONG OLDER PARENTS

INTRODUCTION

Individuals' fertility history (i.e., timing, number, and interval of births) can affect their health trajectories throughout the life course (Grundy and Read 2015; Hanson, Smith and Zimmer 2015; Lacey et al. 2017; Mirowsky 2005; Ning et al. 2020; Williams et al. 2015). This linkage can arise from both physiological and social mechanisms. For example, pregnancy can have direct consequences for maternal health through dramatic hormonal changes and long-term comorbidity (Hanson et al. 2015; Karim et al. 2016; Ryan et al. 2009). Fertility history can also affect multiple dimensions of individuals' social life, such as educational attainment, labor force participation, marital stability, and social integration, which are important determinants of well-being for both men and women (Read and Grundy 2017; Umberson et al. 2010). A branch of the literature has also examined the association and mechanisms between fertility history and its long-term impact on parents' cognitive ability, but most research in this area used clinical data with small samples and has predominantly focused on women and on physiological mechanisms (e.g., Karim et al. 2016; Ryan et al. 2009). Hence, empirical evidence on this association for both genders in the U.S. using population-based data is very limited.

As the aging population increases in many countries, cognitive impairment is becoming more prevalent around the world and has emerged as a rising public health concern in the U.S. as well (Alzheimer's Association 2020; Ray and Davidson 2014). The onset and progression of mild cognitive impairment are associated with an increased risk of developing Alzheimer's or other types of dementia (Alzheimer's Association, 2020). Hence, understanding factors related to the risk of cognitive impairment can help to identify vulnerable populations and to prevent the development of Alzheimer's disease. An increasing number of studies have shown that early or middle life experience can predict a long-term, cumulative impact on individuals' cognitive functioning in later life (Short and Baram 2019; Wang et al., 2019). Fertility or childrearing, as one of the most important life experiences in early or mid-life, can significantly shape one's life contexts, but its impact on cognitive functioning is underexplored in the U.S. In order to explore this fertility-cognition linkage among older adults in the U.S., the present study uses a nationally representative, longitudinal dataset collected over 14 years to examine how timing of first birth and parity can influence the risk of cognitive impairment for both fathers and mothers.

PHYSIOLOGICAL AND SOCIAL MECHANISMS AND A GENDERED PERSPECTIVE

Two types of mechanisms explain how individuals' fertility history potentially influences their cognitive health: *physiological* and *social* mechanisms. First, fertility history is related to physiological changes for women and thus can affect many aspects of maternal health (Hanson et al. 2015; Karim et al. 2016; Najar et al. 2020; Ozalp et al. 2003). These physiological changes in mothers' bodies, either short-term or long-term, can have an impact on mothers' cognitive functioning, both directly and indirectly (Hanson et al. 2015; Karim et al. 2016). Directly, fertility history, such as timing of birth, number of pregnancies, and reproductive period, is related to lifetime exposure to endogenous hormones (progesterone and estrogen), which have been examined as factors associated with the onset or progression of dementia and cognitive impairment (Karim et al. 2016; Najar et al. 2020; Ryan et al. 2009). Indirectly, physiological changes caused by pregnancy can affect later-life comorbidity (e.g., diabetes, heart disease) (Hanson et al. 2015; Lacey et al. 2017), and many chronic diseases have been examined as factors associated with the risk of cognitive impairment (Ahtiluoto et al. 2010; Deckers et al. 2017).

Research on social mechanisms linking fertility and parents' health is often guided by a *life course framework*. Timing is one of the most important principles of the life course approach (Elder 1994, 1995). Individuals develop an expectation of a "normative life cycle," in which certain life events occur at certain ages (Neugarten 1979). Therefore, "off-time" transitions into parenthood often produce life stress and may negatively affect parents' well-being, both physically and mentally (Einiö, Goisis and Myrskylä 2019; Henretta 2008; Koropeckyj-cox et al. 2007; Mirowsky 2005; Neugarten 1979). For example, early fertility timing (i.e., teenage parenthood) often indicates poor preparation for parental roles, interrupts young parents' educational or occupational attainment, and increases the risk of singlehood and marital instability (Koropeckyj-cox et al. 2007; Lacey et al. 2017; Mirowsky 2005). By contrast, giving first birth at a typical age or a slightly delayed age is more likely to benefit parents' well-being because parents often have acquired social resources that help them cope with the costs and stresses of childbearing. Parity (i.e., number of biological children) can also significantly shape parents' social contexts and thus impact their cognitive health. High parity may negatively influence parents' health because a great number of children dissolve parents' economic resources and increase perceived demands (Umberson et al. 2010), reducing parents' time and resources to take care of themselves.

Fertility history can influence men's and women's health differently (Read and Grundy 2017). This is mainly because the biological changes from pregnancy or motherhood is a uniquely female experience. Thus, maternal health is more sensitive to the timing and number of pregnancies. Prior research using clinical data has predominantly focused on how women's fertility history influences their cognitive health in order to explain why incident dementia is more prevalent among older women than older men (Karim et al. 2016; Najar et al. 2020). However, fertility history affects both men's and women's health via social mechanisms, as mentioned above (Einiö et al. 2019; Read and Grundy 2017). Evidence is rare on how the fertility-cognition association varies by gender in the U.S. Therefore, this study will analyze samples of men and women separately in order to better show the gender differences in this association.

In summary, this study will not dig deeply into the direct, biological effects of fertility on cognition (e.g., hormonal changes related to pregnancy) that most clinical research has examined before. Rather, this study will use population-based, nationally representative data to explore indirect pathways through which fertility history influences cognitive impairment. I investigate physiological pathways by examining the mediating effects of health conditions in later life (defined as self-rated health and chronic conditions) and social pathways by examining the mediating effects of socioeconomic status (i.e., education, household income, and wealth). A conceptual framework is described in Figure 4-1.

EMPIRICAL EVIDENCE

Age at First Birth and Parents' Cognitive Health

The association between fertility timing and health problems has been investigated in many studies (Grundy and Read 2015; Hanson et al. 2015; Koropeckyj-cox et al. 2007; Mirowsky 2005; Reibling and Mohring 2018; Williams et al. 2015). Some studies have suggested a U-shaped relationship between age at first birth and health problems in later life, in which either very early or very late first birth can increase parents' health risks, such as lower self-rated health or higher risk of death, chronic diseases, and psychological distress, while a relatively normative or "on-time" first birth can be beneficial to parents' health (Henretta et al. 2008; Lacey et al. 2017; Mirowsky 2005; Pirkle et al. 2014). However, other studies show less consistent findings, especially regarding the effects of late fertility timing on parents' health, with evidence for both positive and negative consequences (Koropeckyj-cox et al. 2007; Lacey et al. 2017; Reibling and Mohring, 2018). This may be largely because different studies have used various cutoff points to define "late" or "delayed" timing of fertility.

The existing literature on how fertility timing influences parents' cognitive health is primarily based on clinical data and female samples and has focused on biological pathways, such as estrogen exposure and hormone therapy (e.g., Karim et al. 2016; Ryan et al. 2009). For example, Ryan and coauthors (2019) analyzed 996 French women age 65 years and older to examine the link between lifetime estrogen exposure and women's cognitive functioning (measured by the Mini-Mental State Examination (MMSE)) in later life. They found that compared to women who gave first birth between ages 21 and 29, those who gave first birth before age 21 had an increased risk of poor cognitive performance over a 4-year follow-up, net of demographic information, lifestyle factors, and health conditions. But they found no difference in risk between those who gave first birth between 21 and 29 and older age groups (30 and older). Karim and coauthors (2016) examined the effects of reproductive history on women's cognitive functioning using data from 830 naturally menopausal women in California. Cognitive status was measured by verbal episodic memory, executive function, and global cognition. They found that later age at *last* pregnancy (>35 years old) was associated with better verbal and cognitive performance. They argued that the benefit of late pregnancy for women's cognition was not attributable to biological mechanisms but rather might reflect socioeconomic and lifestyle factors.

There is limited evidence in this area that uses population-based data and focuses on both men's and women's fertility history. Read and Grundy (2017) used national data from the English Longitudinal Study of Ageing (ELSA) (N = 11,233) to examine the association between fertility history and cognitive functioning for both men and women age 50 and older in England. They found that early age of parenthood (younger than 20 for women, 23 for men) was associated with poorer cognitive functioning for both men and women, but this association was mediated by parents' socioeconomic status, health conditions, and health behaviors. Moreover, late age at *last* birth (older than 35) was associated with better cognitive function for women, net of all other covariates, but no association was found between late fatherhood and fathers' cognitive functioning. They attributed this connection between late birth and better cognitive status for women to the cognitive stimulation from social interaction with young children (e.g., reading, playing games, helping with homework) (Read and Grundy 2017). Notably, both Karim et al. (2016) and Read and Grundy (2017) measured late parenthood using the age at *last* birth instead of *first* birth, so their findings may or may not be applicable for evaluating the effects of age at *first* birth on parents' cognition.

As the present study also uses population-based data with a gendered perspective, I hypothesize that

H1-1: Age at first birth is associated with parents' risk of cognitive impairment for both fathers and mothers as follows: early age at first birth increases the risk while delayed first birth does not increase the risk.

H1-2: The association between age at first birth and risk of cognitive impairment is more profound for mothers than fathers.

H1-3: The association between age at first birth and risk of cognitive impairment is mediated by parents' socioeconomic status and health conditions in later life.

Parity and Parents' Cognitive Health

Parity (i.e., number of biological children) has often been considered as a factor influencing parents' health, especially maternal health, but findings have been mixed (Högnäs et al. 2017; Keenan and Grundy 2019; Ning et al. 2020; Pirkle et al. 2014). For example, some studies have found a significant J-shaped association between parity and parental mortality and health risks (Keenan and Grundy 2019; Högnäs et al. 2017). That is, the risk decreases as parity increases up to 2-3 children but elevates at higher levels of parity for both men and women. However, other studies show little association between parity and parents' health (Pirkle et al. 2014; Reibling and Mohring 2018; Ward et al. 2009). A common conclusion is that the presence of children, the timing or interval of fertility, and intergenerational quality likely matter more to parents' well-being than the number of children or births (Ward et al. 2009; Umberson et al. 2013).

Existing evidence on the association between parity and parents' cognitive health has predominantly focused on female samples. For example, Bae and coauthors (2020) pooled data on women age 60 or older from six population-based studies across four European and two Asian countries to investigate the association between parity and incident dementia. They found that higher parity (5 or more children) increased the risk of dementia by 30% compared to lower parity (1-4), net of parents' education and chronic conditions (Bae et al. 2020). Another population-based study in Singapore analyzed data on women ages 45-74 and found similar results (Song et al. 2020). That is, compared to women with lower parity (1-2 children), those who had high parity (more than 5 children) showed an increased risk of cognitive impairment in later life (Song et al. 2020). These two studies attributed this association to biological mechanisms such as high-density lipoprotein (HDL) levels, changes in glucose metabolism, and estrogen exposure (Bae et al. 2020; Song et al. 2020).

A small group of studies, including samples of both men and women, has explained the association between parity and cognition through social mechanisms. For example, Ning and coauthors (2020) investigated the association between parity and long-term cognitive changes using data from the UK (N = 303,196). Cognitive function was measured by response time, visual memory, and relative brain age (RBA) based on magnetic resonance imaging (MRI) data. This study found that compared to childless people, only parents with two or three children showed faster response time, more accurate visual memory, and significantly younger brain age, more so for men than for women. The authors suggested that lifestyle factors related to parenthood (e.g., less drinking and smoking, more interaction and support from children) rather than the physical process related to pregnancy contributed to this association (Ning et al. 2020). Similarly, Read and Grundy's (2017) study in England suggested that compared to medium parity (2 children), low (0-1 child) and high parity (3 and more children) were associated with poorer cognitive functioning for both men and women. This association was mediated by older adults' socioeconomic status and health conditions.

Following the consistent evidence on the negative effects of high parity on cognitive health, I offer the following hypotheses:

H2-1: Parity is associated with parents' risk of cognitive impairment for both fathers and mothers as follows: high parity (>5 children) increases the risk of cognitive impairment while low and medium parity do not increase the risk.

H2-2: The association between parity and risk of cognitive impairment is more profound for mothers than for fathers.

H2-3: The association between parity and risk of cognitive impairment is mediated by parents' socioeconomic status and health conditions in later life.

DATA AND METHODS

Data

This study used the data from the Health and Retirement Study (HRS) 2000-2014. The HRS is a nationally representative, longitudinal panel data set that is collected biennially by the Institute for Social Research at the University of Michigan. The HRS is applicable to the current research question because of its large sample size, long-term follow-up, high response rates (81%-89%), and high-quality measures of cognitive health and family relationships among adults age 50 and older. The analytical variables are from the RAND HRS Longitudinal File, RAND HRS family data, Cross-Wave Imputation of Cognitive Functioning Measures, and the latest Tracker File. The RAND HRS family data contain variables related to the respondent's family, including characteristics of all children and spouses and summary measures of parents and siblings. As the earliest wave including completed cognition measures is 2000 and the latest cleaned version of family data is in 2014, this study restricted the longitudinal sample from 2000 to 2014. The baseline wave (2000) surveys a sample of 19,579 adults and their spouses.

I restricted the final sample to respondents who aged 50 and older in all waves (1.87% of respondents under age 50 were excluded). As the age at first birth was derived by subtracting the age of the oldest child from the parents' current age, the final sample only included parents who had biological children and excluded parents who had stepchildren, other types of children, and childless respondents. I further excluded missing values in key variables of analysis (0.56%) as well as likely coding errors in age at first birth (negative number, younger than 13, and older than 60) (0.73%). The final analytical sample includes 11,026 respondents (5,016 fathers and 6,010 mothers), contributing to 50,185 person-period records across 8 waves over 14 years.

Measures

<u>*Outcome Variable: Cognitive Impairment*</u>

I included both self-report respondents and proxy-report respondents who could not participate in the survey due to health issues or death (Langa et al. 2009). For self-report respondents, the HRS assesses cognition using the modified version of the Telephone Interview for Cognitive Status (TICS). A final test score was calculated by summing the following cognitive items: immediate and delayed recall of a list of 10 words (1 point for each), five trials of serial 7s (i.e., subtract 7 from 100, and continue subtracting 7 from each subsequent number for a total of five trials, 1 point for each trial), and backward counting (2 points). The final score ranges from 0 (severely impaired) to 27 (high functioning) (Crimmins et al. 2016; Liu et al. 2020). Respondents whose scores were 0-11 were classified as having cognitive impairment; those whose scores were 12-27 were classified as having normal cognition (Crimmins et al. 2016). For proxy-report respondents, respondents' cognitive status was measured by an 11-point scale using the proxy's assessments of (a) the respondent's memory (0 = excellent, 4 = poor) and (b) the respondent's limitations in five instrumental activities of daily living (IADLs): managing money, taking medication, preparing hot meals, using the phone, and shopping for groceries (0–5), as well as (c) the interviewer's assessment of the respondent's difficulty completing the interview because of cognitive limitations (0 = none, 1 = some, and 2 = prevented completion) (Liu et al. 2020). Proxy respondents with a summary score of 3-11 were classified as having cognitive impairment, and those with a score of 0-2 were classified as having normal cognition (Crimmins et al. 2016).

Independent Variables: Fertility History

Age at first birth (time-invariant) was calculated by subtracting the age of the oldest child from the parents' current age at the baseline wave (Mirowsky 2005). The definition of oldest child was restricted to biological children only. Ages at first birth younger than 13 and older than 60 were regarded as misreported and deleted (Mirowsky 2005). Fathers' age at first birth ranges from 13 to 55, and mothers' age at first birth ranges from 13 to 54 in the final sample. In the analysis, ages at first birth for men and women were centered at their respective mean values (rounding integer; mean of men = 26, mean of women = 23).

Number of biological children (time-varying) was based on a question asking respondents, "How many children you have fathered/given birth to, excluding miscarriages or stillbirths and adopted or step-children?" Number of biological children for men ranged from 1 to 18, and for women from 1 to 19. In the analysis, number of biological children was centered at the mean value for men and women (rounding integer; mean = 3 in both cases).

Mediators: Socioeconomic Status and Health Conditions

Socioeconomic status (SES) included three variables: (1) Educational attainment at baseline (time-invariant) was coded into four categories, including less than high school (reference), high school degree, some college, and college and above; (2) Household income (time-varying) was measured by respondent's and spouse's income from all sources for the last calendar year (e.g., earnings, pensions, Social Security benefits, unemployment and workers compensation, etc.); and (3) Net value of total wealth (time-varying) was measured by the sum of all wealth components (e.g., the net value of primary residence, vehicles, business, stocks, etc.) minus all debt (e.g., mortgages, home loans). Missing values for household income and wealth were imputed by RAND HRS. Because these two variables had zero and negative values, I followed the methods in previous studies to adjust them by adding a constant of $1 for both income and wealth and a year-specific constant for wealth (i.e., the minimum value at each wave). By doing this, I transformed both variables into positive values. I further divided the values of household income and wealth by the square root of household size and took the natural logs to adjust for the skewness of the distribution (Zhang and Hayward 2006; Liu et al. 2020).

Health-related factors included two variables: (1) Self-rated health (time-varying) was used as a continuous variable in the analysis, with a higher score representing worse health (1 = excellent, 2 = very good, 3 = good, 4 = fair, 5 = poor), and (2) Chronic conditions (time-varying) was measured by a comorbidity index ranging from 0 to 4, with a higher score representing more comorbidities. The index is a summary score of four major chronic conditions, including diabetes, stroke, heart disease, and high blood pressure.

Covariates

I controlled for several sociodemographic measures for both men and women, including *age* (centered at the means for men and women, respectively), *race/ethnicity* (0 = non-Hispanic white, 1 = non-Hispanic black, 2 = Hispanic, 3 = other), *parents' marital status* (0 = married and cohabiting, 1 = unmarried [divorced, widowed, and never married]). I also controlled for an *indicator of proxy report*, denoting whether cognitive status was reported by a proxy or the respondent (0 = self-report, 1 = proxy-report). *Race/ethnicity* is a time-invariant variable, and other covariates are time-varying across waves.

Analytical Strategy

Preliminary results based on the total sample show that the association between the fertility variables and risk of cognitive impairment displayed non-linear relationships, and there were significant gender differences between fathers and mothers in fertility history. Hence, I used non-linear discrete-time hazard models to estimate the risk of cognitive impairment by the fertility history variables for fathers and mothers, separately. The non-linear discrete-time hazard model is specified as:

$$\log \frac{h(t_{ij})}{1-h(t_{ij})} = \sum_{j=1}^{8} \alpha_j \mathbf{D}_{ij} + \beta_1 \mathbf{X}_i + \beta_2 \mathbf{Y}_{ij} + \beta_3 \mathbf{Z}_{ij}^2$$

where $h(t_{ij})$ indicates the discrete hazard (i.e., conditional probability) of cognitive impairment for individual *i* at time *j*; $\sum_{j=1}^{8} \alpha_j \mathbf{D}_{ij}$ represents the set of intercepts for the eight waves of the HRS from 2000 to 2014; $\mathbf{X}_i$ indicates the vector of time-invariant covariates including age at first birth; $\mathbf{Y}_{ij}$ indicates the vector of time-varying covariates including number of children; $\mathbf{Z}_{ij}^2$ is the quadratic term of fertility history variables (for age at first birth, this is $\mathbf{Z}_i^2$ because it is a time-invariant variable); and β_1, β_2, and β_3 are corresponding coefficient vectors. I reported four models for both fathers and mothers. The first model only adjusts for the effects of basic demographic information, including age (centered), race/ethnicity, marital status, and indicator of proxy-report. The second model adds the effects of the socioeconomic status variables to Model 1, including education, household income, and wealth. The third model adds the effects of health-related factors to Model 1, including self-rated health and chronic conditions. The last model includes both SES and health-related factors. To assist in interpreting the results in each group of models, I created figures to show the predicted probability of cognitive impairment by the fertility variables for both fathers and mothers. I used Stata 15 to estimate the models and generate the figures (StataCorp 2017).

RESULTS

Table 4-1 displays the descriptive statistics of all analyzed variables. 10.34% of respondents reported having cognitive impairment, while 89.66% of respondents had no cognitive impairment. Significant differences between fathers and mothers, marked in the last column, were tested by two-tailed T-test or proportion tests ($p < .05$). Older mothers were more likely to have normal cognition than older fathers. The mean age at first birth for the total sample was around 24 years old, but fathers were almost three years older at first birth than mothers, on average. The mean number of biological children (i.e., average parity) was about 3. Fathers were more likely to have higher parity than mothers. In the sample, mothers were more likely to be younger, non-Hispanic Black, and unmarried, and to have lower levels of educational attainment, household income, wealth, and self-rated health, though they had fewer chronic conditions (higher score = more comorbidities) than fathers. Also, fathers' cognitive status was more likely to be reported by their proxies, but mothers' cognition was more likely to be reported by themselves.

Table 4-2 presents the estimated odds ratios of cognitive impairment from the non-linear discrete-time hazard models for fathers and mothers. The results of Model 1 show the association between fathers' centered age at first birth and risk of cognitive impairment, adjusting for the effects of basic demographic information (i.e., age, race, marital status, and indicator of proxy-report). As both the linear and the quadratic term are significant ($\beta_1 = 0.966$, $p < .001$; $\beta_3 = 1.002$, $p < .001$), the relationship between age at first birth and risk of cognitive impairment for fathers displays a U-shaped (convex) curve, shown in Figure 4-2 (A). This means that both early and late timing of first birth were associated with a higher probability of cognitive impairment for fathers. The optimal ages at first birth, benefiting fathers' cognition most, were from 31 to 37, which is about 5-11 years older than fathers' mean age at first birth (26 years old) in the sample. Model 2 adds health-related factors, and the results are similar to Model 1. The predicted probabilities of cognitive impairment in Model 2, as shown in Figure 4-2 (B), also display a U-shaped curve, although the probabilities decrease slightly among fathers who had very early and very delayed first births. Model 3 adds the effects of socioeconomic status (i.e., education, household income, and wealth) without controlling for fathers' health conditions. Compared to Model 1, the results in Model 3 show reduced effects of age at first birth on risk of cognitive impairment, according to both the smaller odds ratios and lower magnitude of significance. Figure 4-2 (C) shows the predicted results in Model 3. The arc of the curve is much flatter compared to Figure 4-2 (A), suggesting that the probability of cognitive impairment for fathers is less sensitive with respect to changes in age at first birth after adjusting for the effects of SES. Last, Model 4, including both SES and health conditions, shows a similar pattern as Model 3, and the predicted results also create a flatter curve (Figure 4-2 (D)). These results suggest that SES factors may have a stronger mediating effect than health conditions for the association between fertility timing and risk of cognitive impairment among fathers.

Models 5, 6, 7, and 8 in Table 4-2 show the association between age at first birth and risk of cognitive impairment for mothers. Model 5 and Figure 4-3 (E) suggest a J-shaped relationship between mothers' age at first birth and risk of cognitive impairment, adjusting for the effects of basic demographic information. A very early timing of first birth was associated with a higher risk of cognitive impairment for mothers, which is consistent with fathers' pattern in Figure 4-2 (A). Women who gave first birth from the mean age (=23) to around 11 years later than the mean age showed a stable, low risk of cognitive impairment in later life. Unlike fathers' pattern, however, a very delayed first birth (later than 43 years old) dramatically increased mothers' risk of cognitive impairment, exceeding the hazard from a very early first birth. Adding health conditions in Model 6 did not significantly reduce the association between mothers' age at first birth and risk of cognitive impairment, according to the magnitude of significance, although Figure 4-3 (F) displays slightly decreased probabilities among mothers who had either a very early or a very delayed first birth. By contrast, Model 7, which controlled for SES only, indicates that SES mediated the association between mothers' age at first birth and risk of cognitive impairment, as both the linear and quadratic terms became non-significant. This suggests that, when considering mothers' socioeconomic status, there is no significant relationship between fertility timing and risk of cognitive impairment, as illustrated by Figure 4-3 (G). Model 8 adds the effects of both SES and health conditions. The relationship remained non-significant, which was mainly because of the mediating effects of SES. The predicted results in Figure 4-3 (H) also show a flatter line.

Table 4-3 shows the association between number of biological children (i.e., parity) and risk of cognitive impairment for both fathers and mothers. Models 9-12 basically suggest that fathers' parity and risk of cognitive impairment were not significantly associated (figures not shown but available). Adjusting for the effects of SES and/or health factors did not much change the association. For mothers, however, Models 13-16 indicate that parity was consistently associated with risk of cognitive impairment, net of SES and/or health conditions. Specifically, Model 13 and Figure 4-4 (I) show a J-shaped relationship between mothers' parity and risk of cognitive impairment when controlling for the effects of basic demographic information. This indicates that the probability of cognitive impairment remained stable and low if mothers had low or medium parity (fewer than 6 children, approximately). As parity increased towards more than 10 children, the risk of cognitive impairment was sharply elevated. Model 14, controlling for health factors only, indicates that mothers' health conditions partially mediated the relationship between parity and risk of cognitive impairment, but the quadratic term of parity remained significant. Similar to Figure 4-4 (I), Figure 4-4 (J) also shows a J-shaped pattern, although the probability of cognitive impairment is reduced slightly for mothers with high parity. Model 15, considering the effects of SES, still shows a significant quadratic term of parity, while Figure 4-4 (K) displays a flatter curve, created by lower probabilities of cognitive impairment among mothers with very high parity. Model 16 (Figure 4-4 (L)), considering both SES and health conditions, shows similar results.

DISCUSSION

Prior literature demonstrated that parents' fertility history was associated with their cognitive health in later life, but most of the research in this area used clinical data with small samples, focusing on a direct, biological mechanism among women (Karim et al. 2016; Ryan et al. 2009). Therefore, population-based evidence linking fertility and cognition for both genders is lacking, and research based on U.S. data is rare. In order to address these gaps in knowledge, this study is one of the first investigations to use a nationally representative, longitudinal dataset to explore the association between fertility history and risk of cognitive impairment among older parents in the U.S. Generally, the findings support most of the hypotheses, suggesting that both age at first birth and parity are factors related to parents' risk of cognitive impairment. There are gender differences in these relationships, and parents' socioeconomic status is a potentially important factor that may reduce the negative effects of "off-time" fertility or high parity on cognitive impairment.

First, age at first birth was associated with parents' risk of cognitive impairment for both older fathers and older mothers in the U.S. For fathers, there was a U-shaped relationship between age at first birth and risk of cognitive impairment, suggesting that either early age or late age of first birth increased the risk, while a typical age lowered the risk. For mothers, the relationship shows more of a J-shape because an older age at first birth sharply increased mothers' risk of cognitive impairment, indicating a higher risk from late first birth than from early first birth. These findings are consistent with previous research conducted both in and outside the U.S. (Karim et al. 2016; Mirowsky 2005; Ryan et al. 2009; Reibling and Mohring 2018). For example, Mirowsky's (2005) study in the U.S. found that mothers' health problems dropped steadily from first birth during the teenage years to age 34. Then the health problems rose steeply, particularly after age 40 (Mirowsky 2005). Reibling and Mohring's (2018) study in Europe found that late childbearing (older than 35) was detrimental to parents' health (more so for women) but delaying first childbirth until 30 years was beneficial to both mothers' and fathers' health.

The negative effects of "off-time" first birth on cognitive health could be conveyed by both physiological and social mechanisms. Specifically, early age at first birth is associated with a higher risk of health problems for mothers because teenage mothers typically do not have complete development of the reproductive system, which increases the risk to maternal health (Ozalp et al. 2003). Late fertility can also increase mothers' health risks, with high rates of stillbirths, miscarriage, and maternal morbidity and mortality, because aging leads to decreased fecundity as well as deterioration of physiological functions (Restrepo-Méndez et al. 2015; Lisonkova et al. 2017). The comorbidities (e.g., diabetes, heart disease) related to "off-time" fertility could have a long-term negative impact on parents' cognitive health. Moreover, from a life course perspective, "on-time" fertility or slightly delayed parenthood benefits parents' health because parents are better prepared for parental roles and may have sufficient resources to deal with the stress and challenges of childrearing (Koropeckyj-cox et al. 2007). But very delayed fertility could be problematic because the "off-time" transition into parenthood may increase parents' psychological distress and social sanctions from their career and social networks (Koropeckyj-cox et al. 2007; Umberson et al. 2010). Notably, this study's finding of negative effects of late first birth is less consistent with some empirical evidence that has suggested that late fertility benefits parents' cognitive functioning (Karim et al. 2016; Read and Grundy 2017). This may be largely because those studies measured late fertility using age at *last* birth, which may not be applicable to explain the effects of age at first birth on parents' cognition. Also, prior studies often used categorical age at birth rather than continuous measures, neglecting the diversity among parents with late birth (Read and Grundy 2017; Reibling and Mohring 2018).

Second, the present study found that the association between age at first birth and risk of cognitive impairment was mediated by parents' socioeconomic status (SES), but there was less mediating effect of parents' health conditions. Moreover, SES played a stronger role in reducing the negative impact of fertility timing on mothers' risk of cognitive impairment. This finding is consistent with studies on fertility timing and various other health outcomes (e.g., Grundy and Read 2015; Read and Grundy 2017; Spence 2008). For women, education level has been well-recognized as a factor related to fertility timing: college attendance often postpones women's age at first birth (Brand and Davis 2011). Teenage parents often experience education interruption, especially teenage mothers, which can lead to a cumulative disadvantage in occupational attainment, sources of income, and union stability, and thus eventually have a long-term impact on parents' well-being (Brand and Davis 2011; Mollborn 2007). The present study indicates the possibility that continuous education or better economic resources in later life can largely reduce this negative consequence of "off-time" parenthood on parents' cognitive health. A possible explanation is that women with higher SES are more likely to use hormone therapy (Karim et al. 2016), which has been examined as a beneficial factor for a number of cognitive domains (Karim et al. 2016; Ryan et al. 2009; Song et al. 2020). Women's social contexts, especially education level and SES, are important determinants of the use of hormonal contraception. Another likely explanation is the "survivor effect" among parents who had "off-time" parenthood but live longer. Prior research has indicated that teenage parents and parents who had very late first birth often show a higher risk of mortality and morbidity (Henretta et al. 2008; Lacey et al. 2017; Mirowsky 2005; Pirkle et al. 2014). They are more likely to be lost to follow-up, with the result that parents with an "off-time" first birth in the final sample are "survivors" with more agency or resources to cope with the negative effects of early or late parenthood. Interestingly, the negative effects of "off-time" first birth on fathers' cognitive health were not fully mediated by SES, and late first birth was associated with a higher risk than early first birth for fathers. As existing evidence regarding fatherhood and fathers' cognition is very limited, the robustness of this finding should be tested by future studies.

Parity was associated with risk of cognitive impairment, but only for mothers. This finding is consistent with prior evidence on the association between parity and maternal health, showing negative consequences of high parity on women's health outcomes, including cognitive health (Song et al. 2020). This association between women's parity and cognition is consistent and robust regardless of women's SES and health conditions in later life, which suggests a strong possibility of a direct, biological mechanism linking parity and cognition among women. Clinical evidence has confirmed the association between a greater number of pregnancies and risk of cognitive impairment, indicating that changes in estro-progestinic ratio during pregnancy or an increased exposure to progesterone and/or estrogen can escalate the risk of cognitive decline or

Alzheimer's disease (Colucci et al. 2006; Kobayashi et al. 2012; Najar et al. 2020). Moreover, high parity often correlates to short intervals between pregnancies, longer reproductive periods, and/or later menopause, which are factors related to a higher risk of cognitive impairment (Najar et al. 2020).

This study is not without limitations. First, there is likely to be a selection effect in this study. Older people who had lower cognitive status, "off-time" fertility, or high parity were more likely to be lost to follow-up. Therefore, some variations in the sample may be reduced, and the negative effects of "off-time" fertility or high parity on parental cognition are likely to have been underestimated. Second, in order to calculate parents' age at first birth, the analytical sample was restricted to parents who had biological children only. Non-parents who potentially had fertility history (i.e., miscarriage, stillbirth) were excluded. Future studies can use a broader definition of fertility history to test if this relationship exists among a larger population. Third, the sample in this study is composed of specific cohorts who were born before the 1950s in the U.S. It cannot be known whether these findings are applicable to all U.S. people. Prior studies have shown that more recent cohorts may expect first birth after age 30 or a smaller number of children (Reibling and Mohring 2018). Also, with the changing social norms and increasing use of assisted reproductive technology, the timing of first birth may become less important to individuals' health in younger cohorts. Future studies can explore how the linkage between fertility and cognition varies by cohorts. Last, the association between fertility and cognition, especially parity and cognition, could be affected by unmeasured factors, making the study assumption biased. Future research can test more covariates, such as levels of social integration (e.g., activities, contacts, social isolation) or personality factors.

CONCLUSION

Despite these limitations, this study has a number of strengths. This is one of the first studies using nationally representative, longitudinal data to examine the association between fertility history and risk of cognitive impairment among both older fathers and older mothers in the U.S. As most prior studies were based on clinical data with small samples, this study makes a valuable addition by using a large-scale, population-based sample. Moreover, the findings confirmed the negative effects of "off-time" fertility and high parity on parents' risk of cognitive impairment. The strong mediating effects of socioeconomic status on the association between fertility timing and cognitive impairment among mothers indicates that more financial or social support should be provided to women who had "off-time" parenthood. Indeed, given the changing fertility patterns and the increasing size of the aging population, understanding fertility history and its impact on cognition over the life course will help with identifying the most vulnerable subpopulations so that more effective interventions can be made to improve cognitive functioning among older adults.

CHAPTER 5

CONCLUSION

The linkage between parenthood and cognitive health has long been understudied. This dissertation contributes to the broad literature on parenthood and well-being by examining how parental status, parent-child relationship quality, and fertility history influence parents' cognitive functioning as well as potential gender variations. The analysis based on longitudinal, national representative data supports the theoretical predictions that parenthood is linked to parents' cognitive health. Specifically, the first study indicates that being childless and having stepchildren only are possible risk factors to higher risk of cognitive impairment, while having adult children, especially adult daughters and biological children are potential protective factors in lowering this risk. The second study suggests that frequent contact with children and relationship support from children are associated with better cognitive functioning, while relationship strain with children is associated with lower cognitive functioning, more so for older mothers than older fathers. Finally, the third study focuses on parents' fertility history, demonstrating the negative effects of "off-time" fertility and high parity on parents' risk of cognitive impairment.

Demographic transitions trigger greater complexities in family formations and parenting experience, placing new issues on how these changes could influence older adults' well-being, including not only physical and psychological outcomes but also cognitive health. This project highlights that parenthood, as a factor shaping one's life contexts, can be a potential protective or risk factor to individuals' cognitive health in later life. The findings help to identify the most vulnerable subpopulation who may encounter greater risk of cognitive deficits, such as childless older adults, parents with stepchildren only, parents who experienced relationship strain with children, or parents who had “off-time” fertility or high parity. This project not only contributes to a deeper understanding of parenthood and family life course literature but also provides population-based evidence that can speak to medical practitioners, social workers, and policymakers so that more effective interventions could be made to promote older adults’ cognitive well-being as well as successful aging.

APPENDICES

APPENDIX A: CHAPTER 2 TABLES

Table 2-1. Descriptive Statistics of Person-period Files (Unweighted Frequencies and Weighted Proportions), NHATS, 2011-2019, Total N of Respondents = 7,498, Total N of Person-periods = 27,243

Variables	N	%	Variables	N	%
Cognitive health					
Normal cognition (ref)	23,713	90.07	Gender		
Cognitive impairment	3,530	9.93	Female (ref)	16,085	57.32
Parental status			Male	11,158	42.68
Childless (ref)	2,321	8.95	Age groups		
At least one child	24,922	91.05	65-69 (ref)	2,811	15.61
Number of children (ref: no child)			70-74	6,469	30.52
1 child	3,212	11.04	75-79	6,558	24.29
2 children	6,974	27.37	80-84	5,569	15.93
3 children	6,173	23.52	85-89	3,711	9.36
4 and more children	8,563	29.12	90+	2,125	4.30
Children's gender (ref: no child)					
Son(s) only	4,286	16.51	Race/ethnicity		
Daughter(s) only	4,525	16.25	Non-Hispanic White (ref)	20,522	84.77
Both son(s) and daughter(s)	16,111	58.30	Non-Hispanic Black	4,906	7.08
Step parenthood (ref: no child)			Hispanics	1,168	5.09
Bio/adopted children only	21,479	77.80	Others	647	3.05
Stepchildren only	453	1.87	Education		
Both bio/adopted and stepchildren	2,990	11.38	Less than high school (ref)	5,120	15.80
Parent's marital status			High school	9,389	34.64
Married (ref)	13,344	54.77	Some college	9,046	34.55
Cohabiting	540	2.48	College above	3,688	15.01
Divorce	3,387	12.40	Proxy report		
Widowed	8,987	26.77	No (ref)	26,732	98.40
Never married	985	3.58	Yes	511	1.60

Table 2-2. Adjusted Odds Ratios from Discrete-time Hazard Models, Parental Status and Cognitive Impairment, NHATS 2011-2019, Total N of Respondents = 7,498, Total N of Person-periods = 27,243

	M1		M2		M3		M4	
	Odds Ratios	SEs	Odds Ratios	SEs	Odds Ratios	SEs	Odds Ratios	SEs
Having at least one adult child (ref: no child)	0.81*	(0.08)						
Number of children (ref: no child)								
one child			0.86	(0.09)				
two children			0.82	(0.09)				
three children			0.78*	(0.08)				
four or more children			0.81*	(0.08)				
Children's gender (ref: no child)								
son(s) only					0.83	(0.08)		
daughter(s) only					0.75*	(0.08)		
both son(s) and daughter(s)					0.83	(0.08)		
Having bio or stepchildren (ref: no child)								
biological children only							0.82*	(0.08)
stepchildren only							0.71	(0.17)
both bio and stepchildren							0.75*	(0.10)
Male (ref: female)	1.31***	(0.08)	1.31***	(0.08)	1.31***	(0.08)	1.32***	(0.08)
Age group (ref: 65-69)								
70-74	1.38*	(0.17)	1.39**	(0.17)	1.38*	(0.17)	1.38*	(0.17)
75-79	2.32***	(0.21)	2.32***	(0.21)	2.31***	(0.21)	2.31***	(0.21)
80-84	3.63***	(0.36)	3.63***	(0.36)	3.63***	(0.36)	3.61***	(0.36)
85-89	5.64***	(0.70)	5.64***	(0.69)	5.65***	(0.70)	5.60***	(0.70)
90+	8.25***	(1.06)	8.21***	(1.04)	8.30***	(1.07)	8.21***	(1.05)

Note: *** p<0.001, ** p<0.01, * p<0.05

Table 2-2 (cont'd)

	M1		M2		M3		M4	
Variables	Odds Ratios	SEs	Odds Ratios	SEs	Odds Ratios	SEs	Odds Ratios	SEs
Race/ethnicity (ref: Non-Hispanic White)								
Non-Hispanic Black	1.73***	(0.11)	1.73***	(0.11)	1.74***	(0.11)	1.74***	(0.11)
Hispanic	2.06***	(0.20)	2.06***	(0.20)	2.06***	(0.20)	2.05***	(0.20)
Others	1.81**	(0.40)	1.80**	(0.40)	1.82**	(0.40)	1.81**	(0.40)
Education (ref: less than high school)								
High school	0.56***	(0.03)	0.55***	(0.03)	0.56***	(0.03)	0.55***	(0.03)
Some college	0.42***	(0.03)	0.42***	(0.03)	0.42***	(0.03)	0.42***	(0.03)
College above	0.31***	(0.03)	0.31***	(0.02)	0.31***	(0.03)	0.31***	(0.03)
Proxy report (ref: self-report)	8.11***	(1.29)	8.11***	(1.30)	8.11***	(1.29)	8.10***	(1.30)
Parent's marital status (ref: married)								
Cohabiting	0.91	(0.18)	0.91	(0.18)	0.91	(0.18)	0.92	(0.17)
Divorce	1.33***	(0.08)	1.32***	(0.08)	1.33***	(0.08)	1.32***	(0.08)
Widowed	1.26***	(0.08)	1.26***	(0.08)	1.26***	(0.08)	1.26***	(0.08)
Never married	1.10	(0.20)	1.09	(0.20)	1.10	(0.20)	1.09	(0.20)

Note: *** p<0.001, ** p<0.01, * p<0.05

Table 2-3. Adjusted Odds Ratios from Discrete-time Hazard Models Excluding Cognitive Impairment Cases at Baseline, NHATS 2011-2019, Total N of Respondents = 5,519, Total N of Person-periods = 25,264

	M1		M3		M2		M4	
Variables	Odds Ratios	SEs	Odds Ratios	SEs	Odds Ratios	SEs	Odds Ratios	SEs
Having at least one child (ref: no child)	0.81	(0.09)						
Number of children (ref: no child)								
one child			0.88	(0.12)				
two children			0.8	(0.10)				
three children			0.77*	(0.10)				
four or more children			0.82	(0.10)				
Children's gender (ref: no child)								
son(s) only					0.84	(0.12)		
daughter(s) only					0.72*	(0.10)		
both son(s) and daughter(s)					0.83	(0.10)		
Having bio or stepchildren (ref: no child)								
biological children only							0.81	(0.09)
stepchildren only							0.92	(0.25)
both bio and stepchildren							0.82	(0.13)
Male (ref: female)	1.25**	(0.09)	1.25**	(0.09)	1.25**	(0.09)	1.25**	(0.09)
Age group (ref: 65-69)								
70-74	1.24	(0.24)	1.24	(0.24)	1.23	(0.24)	1.24	(0.24)
75-79	2.10***	(0.29)	2.10***	(0.29)	2.09***	(0.30)	2.10***	(0.29)
80-84	3.21***	(0.47)	3.21***	(0.47)	3.20***	(0.47)	3.22***	(0.47)
85-89	4.69***	(0.78)	4.68***	(0.78)	4.70***	(0.79)	4.71***	(0.79)
90+	6.65***	(1.21)	6.59***	(1.20)	6.68***	(1.21)	6.67***	(1.21)

Note: *** $p<0.001$, ** $p<0.01$, * $p<0.05$

Table 2-3 (cont'd)

	M1		M2		M3		M4	
Variables	Odds Ratios	SEs	Odds Ratios	SEs	Odds Ratios	SEs	Odds Ratios	SEs
Race/ethnicity (ref: Non-Hispanic White)								
Non-Hispanic Black	1.74***	(0.15)	1.72***	(0.15)	1.74***	(0.15)	1.74***	(0.15)
Hispanic	1.99***	(0.27)	1.98***	(0.27)	1.99***	(0.27)	1.99***	(0.27)
Others	1.32	(0.26)	1.30	(0.26)	1.33	(0.26)	1.31	(0.26)
Education (ref: less than high school)								
High school	0.67***	(0.05)	0.67***	(0.05)	0.67***	(0.05)	0.67***	(0.05)
Some college	0.52***	(0.05)	0.52***	(0.05)	0.52***	(0.05)	0.52***	(0.05)
College above	0.37***	(0.04)	0.37***	(0.04)	0.37***	(0.04)	0.37***	(0.04)
Proxy report (ref: self-report)	8.73***	(1.79)	8.74***	(1.79)	8.74***	(1.79)	8.72***	(1.78)
Parent's marital status (ref: married)								
Cohabiting	1.06	(0.23)	1.06	(0.23)	1.05	(0.23)	1.05	(0.22)
Divorce	1.38***	(0.11)	1.38***	(0.11)	1.39***	(0.11)	1.39***	(0.11)
Widowed	1.24**	(0.09)	1.24**	(0.09)	1.24**	(0.09)	1.24**	(0.09)
Never married	0.90	(0.18)	0.90	(0.18)	0.91	(0.19)	0.90	(0.19)

Note: *** p<0.001, ** p<0.01, * p<0.05

APPENDIX B: CHAPTER 3 TABLES

Table 3-1. Descriptive Statistics of All Analytic Variables, HRS 2006-2016

Variables	Mean (SD) or %			
	Total (N=13,386)	Fathers (n=5,474)	Mothers (n=7,912)	
Cognitive function 2008	15.14 (4.47)	14.73 (4.28)	15.41 (4.58)	*
Cognitive function 2010	14.78 (4.50)	14.44 (4.33)	15.00 (4.59)	*
Cognitive function 2012	14.54 (4.53)	14.18 (4.32)	14.78 (4.65)	*
Cognitive function 2014	14.59 (4.66)	14.35 (4.45)	14.74 (4.79)	*
Cognitive function 2016	14.41 (4.65)	14.21 (4.48)	14.53 (4.75)	*
Contact frequency 2006/08	4.59 (1.10)	4.38 (1.17)	4.73 (1.02)	*
Contact frequency 2010/12	4.54 (1.11)	4.32 (1.17)	4.69 (1.04)	*
Contact frequency 2014/16	4.44 (1.12)	4.22 (1.16)	4.58 (1.07)	*
Relationship support 2006/08	3.28 (0.71)	3.17 (0.75)	3.36 (0.67)	*
Relationship support 2010/12	3.29 (0.71)	3.17 (0.76)	3.37 (0.66)	*
Relationship support 2014/16	3.31 (0.70)	3.20 (0.74)	3.37 (0.67)	*
Relationship strain 2006/08	1.70 (0.63)	1.68 (0.62)	1.71 (0.64)	*
Relationship strain 2010/12	1.66 (0.62)	1.63 (0.61)	1.67 (0.63)	*
Relationship strain 2014/16	1.64 (0.64)	1.62 (0.62)	1.65 (0.64)	
Baseline Covariates				
Age (years)	68.00 (9.75)	68.22 (9.31)	67.85 (10.04)	*
Race (%)				
Non-Hispanic White	76.47	78.53	75.04	*
Non-Hispanic Black	12.68	10.94	13.88	*
Hispanic	6.36	6.05	6.57	
Other	4.50	4.48	4.51	
Education (%)				
Less than high school	22.55	22.67	22.46	
High school	34.80	30.64	37.68	*
Some college	31.88	32.23	31.65	
College graduate or above	10.77	14.47	8.22	*
Marital status (%)				
Married	69.05	84.33	58.48	*
Unmarried	30.95	15.67	41.52	*
RQ survey starting year (%)				
Since 2006	53.94	54.53	53.53	
Since 2008	46.06	45.47	46.47	

Note: *Statistically significant difference by gender at the $p < 0.05$ level. SD: Standard Deviation

Table 3-2. Effects of Relationship Quality on Cognition from Latent Growth Curve Models, HRS 2006-2016, Total Sample (N=13,386)

	A. Contact Frequency		B. Positive Relationship		C. Negative Relationship	
	Latent Intercept	Latent Slope	Latent Intercept	Latent Slope	Latent Intercept	Latent Slope
RQ intercept	0.308***	-0.011	0.490***	-0.012	-0.796***	0.001
	(0.045)	(0.007)	(0.068)	(0.011)	(0.080)	(0.013)
RQ slope		0.615**		1.503		-1.061*
		(0.227)		(0.858)		(0.415)
Baseline Covariates						
Age (centered at mean)	-0.145***	-0.014***	-0.151***	-0.014***	-0.156***	-0.013***
	(0.003)	(0.001)	(0.003)	(0.001)	(0.004)	(0.001)
Gender (ref: male)						
Female	0.839***	-0.040***	0.847***	-0.037***	0.961***	-0.044***
	(0.066)	(0.010)	(0.066)	(0.010)	(0.064)	(0.010)
Race (ref: Non-Hispanic White)						
Non-Hispanic Black	-2.527***	-0.009	-2.564***	-0.008	-2.423***	-0.015
	(0.094)	(0.014)	(0.095)	(0.015)	(0.095)	(0.015)
Hispanic	-1.534***	0.044*	-1.558***	0.046*	-1.476***	0.029
	(0.130)	(0.019)	(0.130)	(0.020)	(0.130)	(0.020)
Other	-2.053***	-0.009	-2.090***	-0.014	-1.994***	-0.007
	(0.148)	(0.022)	(0.148)	(0.023)	(0.148)	(0.022)

Note: RQ: relationship quality between parents and children. Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05

Table 3-2 (cont'd)

	A. Contact Frequency		B. Positive Relationship		C. Negative Relationship	
	Latent Intercept	Latent Slope	Latent Intercept	Latent Slope	Latent Intercept	Latent Slope
Education (ref: less than high school)						
High school	2.319***	0.002	2.297***	0.003	2.288***	0.001
	(0.086)	(0.014)	(0.086)	(0.014)	(0.086)	(0.014)
Some college	3.574***	0.000	3.545***	0.002	3.516***	0.005
	(0.088)	(0.014)	(0.088)	(0.014)	(0.088)	(0.014)
College above	4.797***	0.015	4.732***	0.020	4.688***	0.030
	(0.116)	(0.018)	(0.116)	(0.018)	(0.116)	(0.018)
Marital Status (ref: married)						
Unmarried	-0.226**	-0.018	-0.219**	-0.022*	-0.202**	-0.019
	(0.071)	(0.011)	(0.071)	(0.011)	(0.071)	(0.011)
MQ survey starting year (ref: 2006)						
2008	-0.025	-0.010	-0.041	-0.004	-0.071	0.003
	(0.060)	(0.009)	(0.060)	(0.010)	(0.061)	(0.010)
Means of growth parameters	11.174***	-0.150***	11.015***	-0.187***	13.908***	-0.231***
	(0.219)	(0.038)	(0.229)	(0.035)	(0.164)	(0.028)
Variances in growth parameters	7.045***	0.015***	7.039***	0.015***	6.975***	0.016***
	(0.159)	(0.004)	(0.159)	(0.004)	(0.159)	(0.004)
Model fit index	CFI=0.990, TLI=0.984, RMSEA=0.022		CFI=0.992, TLI=0.986, RMSEA=0.021		CFI=0.991, TLI=0.985, RMSEA=0.021	

Note: RQ: relationship quality between parents and children. Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05

Table 3-3. Effects of Relationship Quality on Cognition from Multiple Group Analysis of Latent Growth Curve Models by Gender, HRS 2006-16

	A. Contact Frequency		B. Positive Marital Quality		C. Negative Marital Quality	
	Latent Intercept	Latent Slope	Latent Intercept	Latent Slope	Latent Intercept	Latent Slope
Fathers (n=5,474)						
RQ intercept	0.294***	-0.009	0.400***	0.010	-0.777***	0.013
	(0.061)	(0.010)	(0.093)	(0.015)	(0.127)	(0.021)
RQ slope		0.978		0.304		-1.137
		(0.590)		(0.853)		(0.742)
Means of growth parameters	11.412***	-0.182**	11.469***	-0.275***	14.076***	-0.285***
	(0.297)	(0.054)	(0.317)	(0.050)	(0.254)	(0.048)
Variances in growth parameters	6.458***	0.005	6.477***	0.007	6.408***	0.006
	(0.232)	(0.006)	(0.232)	(0.006)	(0.231)	(0.006)
Mothers (n=7,912)						
RQ intercept	0.314***	-0.013	0.548***	-0.031*	-0.841***	-0.005
	(0.065)	(0.011)	(0.096)	(0.015)	(0.103)	(0.016)
RQ slope		0.484*		2.777		-1.040*
		(0.234)		(1.712)		(0.503)
Means of growth parameters	11.846***	-0.166**	11.534***	-0.162**	14.786***	-0.242***
	(0.333)	(0.056)	(0.338)	(0.052)	(0.209)	(0.035)
Variances in growth parameters	7.388***	0.021***	7.367***	0.018**	7.291***	0.021***
	(0.216)	(0.005)	(0.215)	(0.006)	(0.215)	(0.005)
Model fit index	CFI=0.990, TLI=0.983, RMSEA=0.023		CFI=0.992, TLI=0.986, RMSEA=0.022		CFI=0.990, TLI=0.984, RMSEA=0.023	

Note: RQ: relationship quality between parents and children. Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05

APPENDIX C: CHAPTER 4 TABLES

Table 4-1. Descriptive Statistics of All Analytical Variables, HRS 2000-2014

	Total (N=50,185)	Men (n=21,668)	Women (n=28,517)	
Variables	Mean (SD)/%	Mean (SD)/%	Mean (SD)/%	
Cognitive status				
Normal cognition (ref)	89.66	88.60	90.47	*
Cognitive impairment	10.34	11.40	9.53	*
Fertility history				
Age at first birth (13-55)	24.00 (4.97)	25.62 (5.16)	22.77 (4.44)	*
Number of biological kids (1-19)	3.09 (1.61)	3.13 (1.63)	3.06 (1.60)	*
Age (50-94)	67.87 (7.41)	68.46 (7.23)	67.43 (7.51)	*
Race				
Non-Hispanic White (ref)	81.99	83.07	81.17	*
Non-Hispanic Black	9.66	8.27	10.71	*
Hispanic	5.33	5.40	5.28	
Other	3.02	3.26	2.84	*
Proxy report indicator				
Self-report (ref)	94.73	90.55	97.90	*
Proxy-report	5.27	9.45	2.10	*
Marital status				
Married (ref)	72.38	86.45	61.69	*
Unmarried	27.62	13.55	38.31	*
Education				
Less than high school (ref)	16.94	16.59	17.21	
High school	36.11	31.40	39.69	*
Some college	33.82	34.19	33.53	
College above	13.14	17.82	9.57	*
Household income (unit: 10k)	6.67 (10.42)	7.69 (11.31)	5.90 (9.62)	*
Wealth (unit: 10k)	57.23 (129.03)	65.18 (137.52)	51,19 (121.84)	*
Chronic condition (0-4)	1.03 (0.94)	1.11 (0.97)	0.96 (0.92)	*
Self-rated health (1-5)	2.70 (1.05)	2.68 (1.04)	2.72 (1.05)	*

Note: Value of wealth includes debts. Significant differences between men and women tested by two-tailed T-test or Proportion test. Marked in the last column. * p<0.05

Table 4-2. Estimated Odds Ratios of Discrete-time Hazard Models, Age at First Birth Predicting Risk of Cognitive Impairment for Fathers and Mothers, HRS 2000-2014

	Fathers (n=21,668)				Mothers (n=28,517)			
Variables	M1	M2	M3	M4	M5	M6	M7	M8
Age at first birth (centered)	0.966***	0.973***	0.987*	0.991	0.948***	0.966***	0.998	1.005
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)
Quadratic age at first birth (centered)	1.002***	1.002***	1.001**	1.001*	1.004***	1.003***	1.001	1.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Age (centered)	1.085***	1.077***	1.077***	1.071***	1.090***	1.082***	1.086***	1.082***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Race/ethnicity (ref: NH White)								
NH Black	2.714***	2.471***	1.883***	1.851***	3.291***	2.858***	2.697***	2.530***
	(0.178)	(0.165)	(0.131)	(0.130)	(0.188)	(0.166)	(0.164)	(0.155)
Hispanic	2.430***	2.068***	1.202*	1.169	3.525***	2.849***	1.640***	1.566***
	(0.198)	(0.172)	(0.106)	(0.105)	(0.263)	(0.217)	(0.135)	(0.129)
Other	1.918***	1.729***	1.337*	1.312*	3.536***	2.999***	2.335***	2.214***
	(0.212)	(0.194)	(0.156)	(0.154)	(0.341)	(0.294)	(0.237)	(0.227)
Proxy report (ref: self-report)	2.777***	2.441***	2.298***	2.116***	5.657***	4.852***	5.534***	5.000***
	(0.169)	(0.153)	(0.145)	(0.136)	(0.552)	(0.489)	(0.565)	(0.519)
Unmarried (ref: married)	1.549***	1.437***	1.457***	1.375***	1.332***	1.235***	1.179***	1.133**
	(0.092)	(0.087)	(0.091)	(0.087)	(0.060)	(0.056)	(0.056)	(0.054)
Chronic condition (0-4)		1.039		1.056*		1.122***		1.096***
		(0.026)		(0.026)		(0.027)		(0.027)
Self-rated Health (1-5)		1.539***		1.392***		1.487***		1.326***
		(0.036)		(0.033)		(0.033)		(0.031)
Education (ref: less than high school)								
High school			0.534***	0.566***			0.448***	0.490***
			(0.031)	(0.034)			(0.024)	(0.027)
Some college			0.384***	0.405***			0.300***	0.343***
			(0.025)	(0.026)			(0.020)	(0.023)
College and above			0.240***	0.274***			0.222***	0.255***
			(0.024)	(0.028)			(0.027)	(0.031)
Household income (logged)			0.855***	0.878***			0.857***	0.877***
			(0.018)	(0.019)			(0.014)	(0.015)
Wealth (logged)			0.668***	0.738***			0.616***	0.682***
			(0.041)	(0.043)			(0.039)	(0.043)

Note: Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05

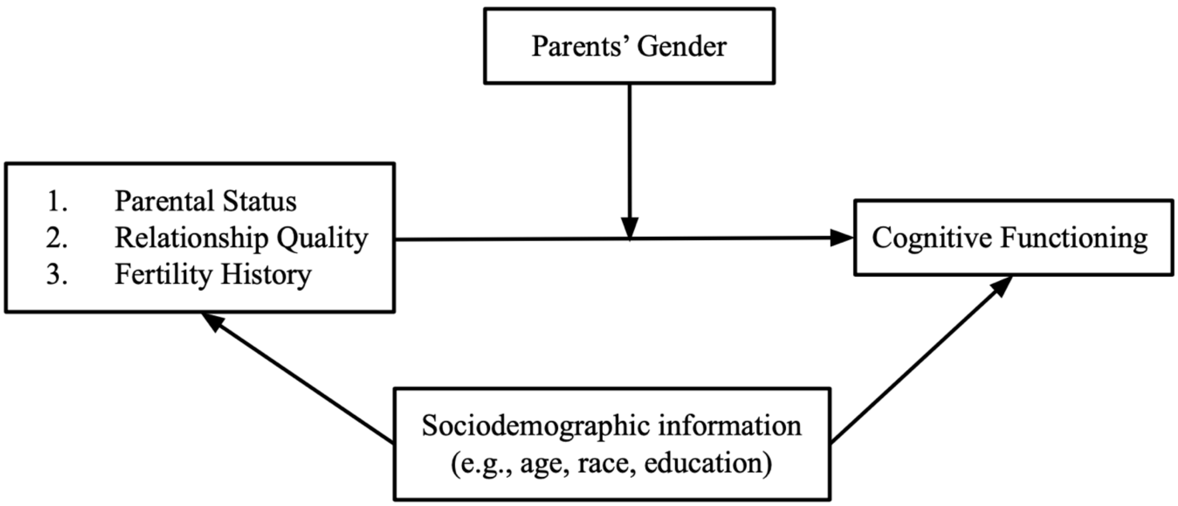
Table 4-3. Estimated Odds Ratios of Discrete-time Hazard Models, Number of Biological Children Predicting Risk of Cognitive Impairment for Fathers and Mothers, HRS 2000-2014

	Fathers (n=21,668)				**Mothers (n=28,517)**			
Variables	M9	M10	M11	M12	M13	M14	M15	M16
Number of children (centered)	1.040*	1.027	0.981	0.980	1.038*	1.023	0.961*	0.962*
	(0.018)	(0.018)	(0.018)	(0.018)	(0.016)	(0.016)	(0.016)	(0.016)
Quadratic number of children (centered)	1.006	1.005	1.006	1.005	1.008**	1.008*	1.008**	1.008**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Age (centered)	1.078***	1.071***	1.074***	1.069***	1.083***	1.077***	1.086***	1.082***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Race/ethnicity (ref: NH White)								
NH Black	2.713***	2.468***	1.894***	1.862***	3.436***	2.906***	2.716***	2.530***
	(0.178)	(0.165)	(0.132)	(0.131)	(0.195)	(0.169)	(0.164)	(0.154)
Hispanic	2.263***	1.953***	1.179	1.156	3.383***	2.723***	1.641***	1.580***
	(0.186)	(0.164)	(0.104)	(0.103)	(0.254)	(0.209)	(0.134)	(0.130)
Other	1.816***	1.660***	1.322*	1.306*	3.366***	2.875***	2.333***	2.224***
	(0.201)	(0.187)	(0.155)	(0.154)	(0.325)	(0.283)	(0.237)	(0.228)
Proxy report (ref: self-report)	2.820***	2.469***	2.318***	2.132***	5.449***	4.716***	5.500***	4.999***
	(0.171)	(0.154)	(0.146)	(0.137)	(0.530)	(0.475)	(0.562)	(0.519)
Unmarried (ref: married)	1.554***	1.437***	1.450***	1.368***	1.391***	1.266***	1.180***	1.129*
	(0.093)	(0.087)	(0.091)	(0.086)	(0.062)	(0.057)	(0.056)	(0.054)
Chronic condition (0-4)		1.042		1.058*		1.128***		1.094***
		(0.026)		(0.026)		(0.027)		(0.027)
Self-rated health		1.544***		1.394***		1.507***		1.325***
		(0.036)		(0.033)		(0.033)		(0.030)
Education (ref: less than high school)								
High school			0.533***	0.564***			0.443***	0.490***
			(0.031)	(0.034)			(0.024)	(0.027)
Some college			0.376***	0.398***			0.296***	0.346***
			(0.024)	(0.026)			(0.019)	(0.022)
College and above			0.231***	0.267***			0.217***	0.257***
			(0.023)	(0.027)			(0.026)	(0.031)
Household income (logged)			0.855***	0.878***			0.856***	0.877***
			(0.018)	(0.019)			(0.014)	(0.015)
Wealth (logged)			0.667***	0.736***			0.608***	0.674***
			(0.041)	(0.043)			(0.039)	(0.043)

Note: Standard errors in parentheses. *** p<0.001, ** p<0.01, * p<0.05

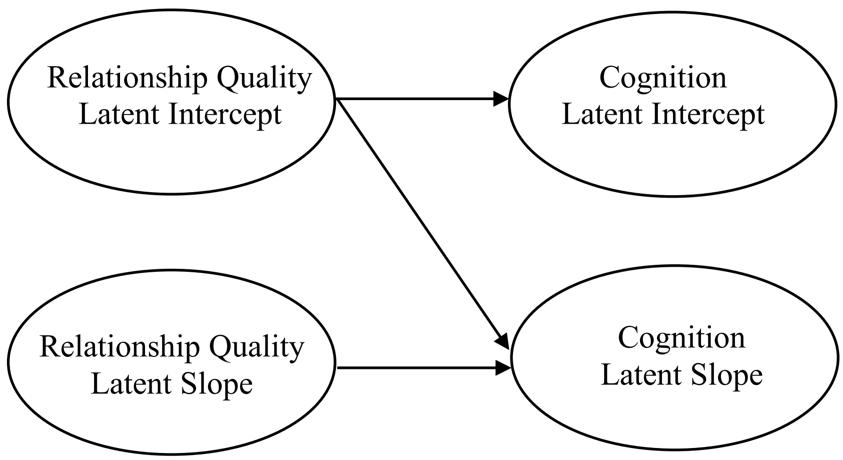
APPENDIX D: CHAPTER 1 FIGURE

Figure 1-1. Conceptual Framework Linking Parenthood and Cognitive Functioning



APPENDIX E: CHAPTER 3 FIGURE

Figure 3-1. Graphical Depiction of A General Latent Growth Curve Model



For simplicity, covariates at baseline (i.e., age, gender, race/ethnicity, education, marital status, and survey year indicator) are not shown.

APPENDIX F: CHAPTER 4 FIGURES

Figure 4-1. Conceptual Framework Linking Fertility History and Risk of Cognitive Impairment

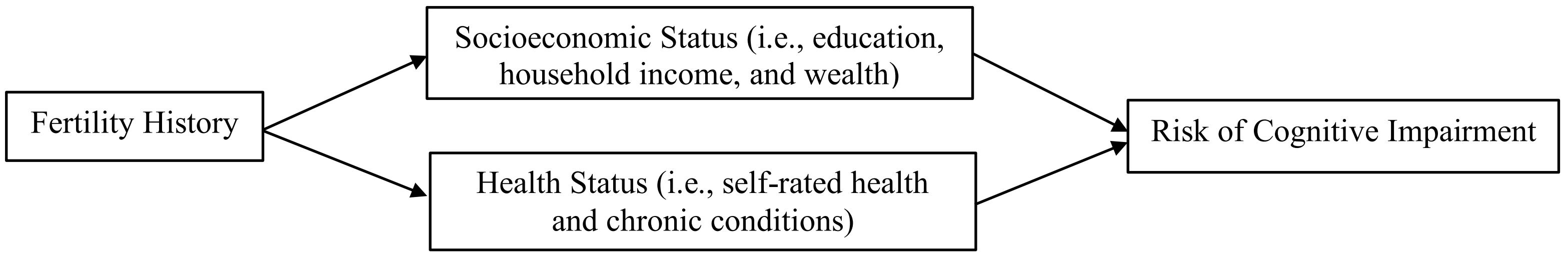
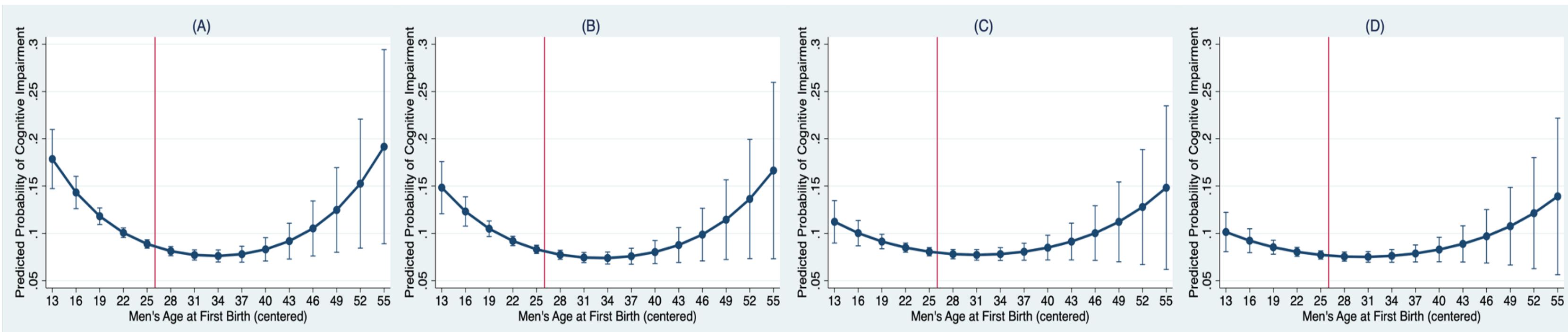
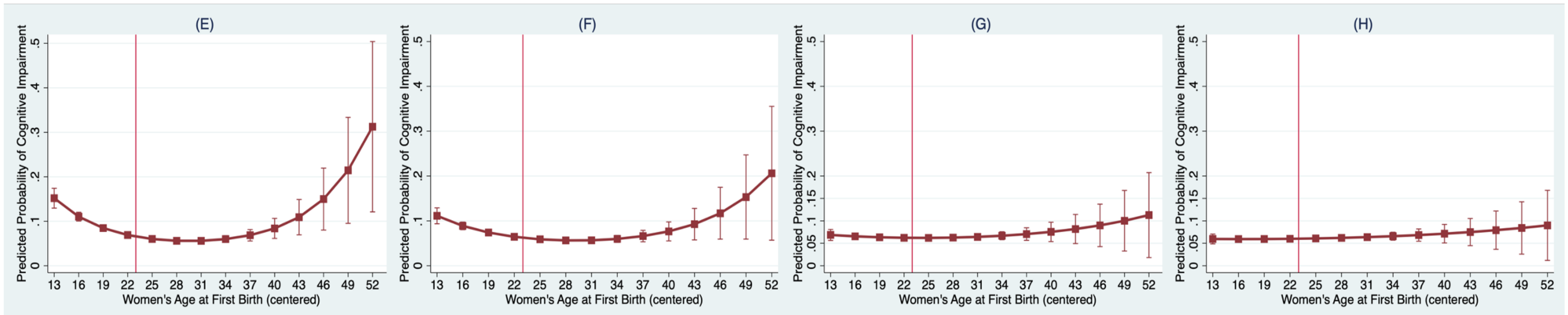


Figure 4-2. Men's Age at First Birth (centered) Predicting the Probability of Cognitive Impairment



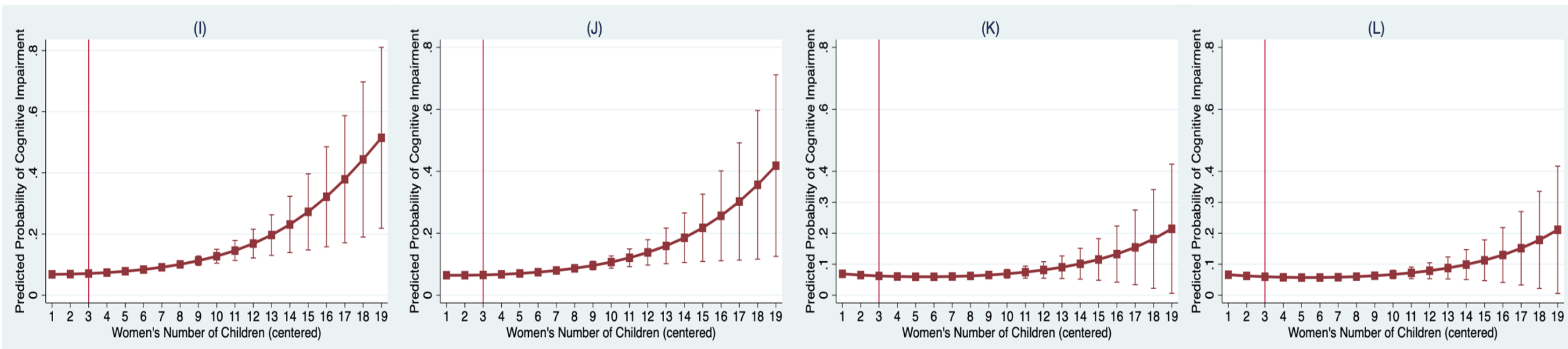
Note: (A), (B), (C), and (D) display predicted results from Model 1, 2, 3, and 4, respectively. The red reference lines represent the mean of men's age at first birth at 26 years old.

Figure 4-3. Women's Age at First Birth (centered) Predicting the Probability of Cognitive Impairment



Note: (E), (F), (G), and (H) display predicted results from Model 5, 6, 7, and 8, respectively. The red reference lines represent the mean of women's age at first birth at 23 years old.

Figure 4-4. Women's Number of Children (centered) Predicting the Probability of Cognitive Impairment



Note: (I), (J), (K), and (L) display predicted results from Model 9, 10, 11, and 12, respectively. The red reference lines represent that the mean number of children for women is 3.

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